Self-Esteem and Obesity: A Longitudinal Analysis among Children and Adolescents in Niagara, Canada

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Abstract

As the prevalence of obesity has surged in the past decade, with a marked increase in the rates among North American youth, it is important to comprehensively understand its downstream effects and the burden these may have on society. Besides the countless physical comorbidities of overweight and obesity in youth, several psychosocial effects have been identified including self-esteem issues.

The purpose of this study is to understand the longitudinal relationship between obesity and self-esteem in Canadian children and adolescents. By quantifying this association, it may not only provide evidence for prevention, but be useful for future resource planning. The research questions are as follows: *Is there a correlation between body mass and self-esteem? Is obesity status and body mass over time associated with changes in self-esteem, and if so among which sub-domains? Is the temporal relationship bi-directional where self-esteem also predicts changes in body mass? Is the relative difference in body mass between those in the same cohort also associated with self-esteem change longitudinally? Which covariate factors are significant in these suggested relationships?*

Data was obtained from the PHAST cohort study conducted from 2004-2010 among 2,278 children at baseline from Niagara, Canada. Participants were excluded if missing all data related to body mass and self-esteem, and multiple imputation regression was utilized to impute missing observations. Cross-sectional analysis between variables was conducted using the Pearson correlation test. Linear mixed modelling regression was conducted to examine the proposed bi-directional relationships longitudinally, accounting for fixed and random variables as well as relevant covariates and interactions.

There were weak to moderate significant negative linear correlations between BMI and all self-esteem sub-domains. Baseline obesity status and BMI increases were significant predictors of decreased physical, global, athletic, and social self-esteem longitudinally. With each kg/m^2 increase in BMI, physical appearance self-esteem was reduced by 0.25 units (95% CI: -0.29, -0.21, $p<0.0001$) over a 5-year period. Compared to those of a normal weight, those obese at baseline had an average athletic self-esteem 1.51 units lower (95% CI: -2.15, -0.87, $p<0.0001$). With each standard deviation increase from the mean BMI of one's sex and age, global self-esteem was reduced by 0.53 units (95% CI: -0.62, -0.43, $p<0.0001$). Also, low baseline self-esteem and decreases in physical, global, and athletic self-esteem levels significantly predicted increased BMI over time. Physical activity was a significant covariate, predicting both increased self-esteem levels and decreased BMI longitudinally.

The results suggest that there is a bi-directional relationship present between body mass and self-esteem in school children. Having a greater body size impairs areas of self-esteem, and having stronger self-esteem helps mitigate obesity. Physical activity is a key factor in maintaining appropriate self-esteem and body mass levels. This study can be used to guide public health officials and resource planners given the escalation of the obesity epidemic in youth.

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*Keywords: childhood obesity, self-esteem, global self-worth, longitudinal, bi-directional

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List of Abbreviations

BE	Body-Esteem
BMI	Body Mass Index
CDC	Centers for Disease Control and Prevention
CI	Confidence Interval
CVD	Cardiovascular Disease
DCD	Developmental Coordination Disorder
DSBN	District School Board of Niagara
DV	Dependent Variable
FCS	Fully Conditional Specification
GSW	Global Self-Worth
IV	Independent Variable
LMM	Linear Mixed Model
NCHS	National Center for Health Statistics
NS	Non-Significant
NW	Normal Weight
OB	Obese
OR	Odds Ratio
OW	Overweight
PA	Physical Activity
PHAST	Physical Health Activity Study Team
RCT	Randomized Controlled Trial
RSES	Rosenberg Self-Esteem Scale
SCS	Self-Concept Scale
SD	Standard Deviation
SDQ	Self-Description Questionnaire
SE	Self-Esteem

SEI	Self-Esteem Inventory
SEQ	Self-Esteem Questionnaire
SES	Socioeconomic Status
Sig.	Significance Level
SPPA	Self-Perception Profile for Adolescents
SPPC	Self-Perception Profile for Children
UAID	Unique Area Identification Code
WC	Waist Circumference
WHO	World Health Organization
WHR	Waist-to-Hip Ratio
WT	Weight

Chapter 1 Introduction

One of the most important public health issues facing the world today is the increasing prevalence of overweight and obesity and their downstream effects. Obesity is defined as an excessive accumulation of fat tissue in the body. The negative effects are not just on individual health and mortality but on society as a whole, as obesity can lead to a massive burden on health resources and the overall health of the population. In the past three decades, obesity rates have nearly tripled worldwide, as the World Health Organization estimates over 1.9 billion adults are overweight, with 13% of adults considered obese (WHO, 2017). This problem is especially prevalent in Western countries like the United States with over 30% obesity rate, as it underlies many major illnesses including cardio-metabolic diseases, musculoskeletal disorders, and some cancers (Ogden, Carroll, Kit, & Flegal, 2012; WHO, 2017)

The dramatically increased presence of overweight and obesity in children has been a global trend, with over 18% of children and adolescents 5-19 years old worldwide being considered overweight or obese, a problem particularly impacting over one third of Canadian children (Roberts, Shields, de Groh, Aziz, & Gilbert, 2012). Children with obesity are at a much higher risk of disability, premature death, and being obese in adulthood, which is associated with several other comorbidities. In the short-term, obese children experience more asthma, fractures, hypertension, cardiovascular problems, insulin resistance, and psychological issues (CDC, 2017; WHO, 2017). Overweight and obese children experience more social difficulties and isolation due to stigma, teasing, and bullying, and experience psychological problems such as body dissatisfaction, anxiety, and depression. These children are also more likely to report lower self-esteem and quality of life (Griffiths, Parsons, & Hill, 2010). In general, childhood obesity has several immediate and long-term impacts on physical, social, and emotional health, and as the prevalence of obesity increases among youth these problems will require much more attention and resources.

Self-esteem, representing one's sense of self-worth, is a psychosocial construct referring to the positive and negative feelings and evaluations people have about themselves including their perceived abilities in various aspects of life (Rosenberg, 1979). Since it is generally defined as the attitude towards oneself, self-esteem may be a stable trait throughout life, or a state which can incur gradual or sudden short and long-term changes (Radziwiłłowicz & Macias, 2014). Low self-esteem is accompanied by dissatisfaction with oneself and may lead to low aspirations and underachievement, increased vulnerability to drug and alcohol abuse, and unhealthy behaviors used in attempt to self-regulate negative emotions (Canetti, Berry, & Elizur, 2009; Wang, Wild, Kipp, Kuhle, & Veugelers, 2009). Having poor self-esteem in youth can lead to significant problems in adulthood including lower socioeconomic status, higher levels of criminal behavior, and poorer physical and mental health outcomes (Trzesniewski et al., 2006).

The relationship between obesity and self-esteem has been relatively well-studied, and a lot of focus has been on youth since their self-esteem levels are more susceptible to external influences and change more drastically (Zhang, Li, Xu, & Zhou, 2016). Overall for both children and adults, obese subjects have significantly lower levels of self-esteem and those who are obese are more likely to have impaired self-esteem (Griffiths et al., 2010). Certain areas of self-esteem have been found to be particularly impacted by higher body mass including social, physical appearance, and athletic self-esteem. Based on the literature which has been mixed, this relationship is significant yet moderate, as several different factors are believed to play a role including sex, age, race, bullying, socioeconomic status, parenting, and physical activity levels. The mechanisms linking overweight and obesity to psychological health problems are not well understood, but it is suggested that peer teasing and social stigma as a result of body size may mediate the inverse relationship.

The up-to-date literature has left pieces of the association unanswered however, as very few longitudinal analyses have been conducted and the causal pathway is still uncertain. As well, there has been a lack of consistency in the inclusion of relevant covariates and mediating factors. The question remains: Is there a significant relationship between obesity and self-esteem in youth over time? And what is the mechanism of this relationship? The directionality of the association has been rarely addressed in the literature, and methodologies in measuring this relationship have been very inconsistent.

Obesity prevention is a major public health priority due to its increasing prevalence and downstream health outcomes including health care system costs. Low self-esteem is one of these associated effects, and is also related to several comorbidities and lower quality of life. The purpose of this study is to further understand the association between body mass and self-esteem, and examine how changes in weight-related measures over time impact changes in self-esteem in Canadian children and adolescents. Subsequently, directionality is addressed by examining the reverse relationship of how changes in self-esteem impact changes in weight measures over time. It will be important to understand which contributing factors are related to these outcomes, so that specific interventions may be planned and targeted at this cohort in the future.

Chapter 2 Literature Review

2.1 Outline

The following review of the literature focuses on three central areas: self-esteem, obesity, and their relationship. For each topic, additional details are expressed specific to children and adolescents. The relevant literature is summarized for each factor and an extensive review of findings is conducted for their relationship, followed by generalized conclusions. Finally, gaps in the literature are identified, and recommendations for further research are discussed.

2.2 Self-Esteem

2.2.1 Theory and definitions. The earliest work in self-esteem was contributed by theorists William James (1890) and Charles Horton Cooley (1902). According to James in his *Principles of Psychology* (James, 1890), self-esteem is derived by the difference between a person's goals or aspirations and their actual attainments, in other words, success divided by objectives. When there is a close match between actual attainments (current self-image) and ideal aspirations (ideal self-image), James believed this constituted high self-esteem. He stated that self-esteem can be increased by achieving greater successes (or by adopting less ambitious pretensions), and maintained by avoiding failures (Emler, 2001). To the question of how people actually know whether they are successful in their goals, Charles Cooley added a social aspect to the framework. Namely, that one's self-esteem and self-evaluation depend on the regard and treatment from others, meaning people assess their own worth based on the judgements they imagine others make of them following their actions (Cooley, 1902). In order to judge how well one is doing at certain activities, social comparisons with others are made (Emler, 2001). This idea has been expanded on by Mark Leary proposing the Sociometer theory, in that self-esteem is primarily a measure of social acceptance by those we have high regard for, dependant on how we describe their relative standing to us. Anything associated with a change in the relations or acceptance with others (e.g. success, failure, rejection, praise, love, hatred) impacts self-esteem (Leary, 1999). Under this theory, feeling low self-esteem is indicative of perceived poor relationships (low relational value), and thus can act as a driving force for behavior change (Emler, 2001). Another postulate suggested in combination by James, Cooley, and Rosenberg is that although an average level of self-esteem exists for an individual, it can be reactive and vary based on the changing circumstances in someone's life. Furthermore, the base-level that exists and its reactivity may be different for each person, potentially based on the strength and stability of one's attitudes towards oneself (Emler, 2001). Thus, in order to make conclusions on the magnitude and changeability of self-esteem, the need to measure, compare, and detect changes in it was necessitated.

Morris Rosenberg first conceptualized measuring self-esteem in terms of generalized global self-appraisal or self-worth, based on the evaluative attitude towards the self and the extent that someone thinks they are a great person overall (Rosenberg, 1965). Rosenberg's belief was that the attitude towards the self is shaped by what others think of us, determined by their reactions. Upon interactions with others, the positive or negative feedback received will be absorbed into one's self-appraisal, with the assumption that how they treat us is based on what they truly think (Cooley, 1902; Emler, 2001; Rosenberg, 1965). Early theorists believed that the self was a unitary construct, and could best be described in young people by summing a range of content related to peers, parents, and school to create a single index measuring overall self-worth. Since then, scholars such as Bruce Bracken (1992) and Susan Harter (2012) have asserted that universal scores can mask distinct self-competencies related to various areas of life. Thus, it was proposed that self-esteem should also be measured using a multidimensional approach among specific age-related domains such as physical, scholastic, and social capacities.

2.2.1.1 Unidimensional approaches. Unidimensional self-esteem (global self-worth) is assessed as the overall attitude people have towards themselves and their self-perceived worth as a person. Rosenberg created the 10-item Rosenberg Self-Esteem Scale (RSES), which asks for the level of agreement on statements about oneself. This scale is indicated for adolescents and adults, and yields a single score as the sum of positive feelings about oneself, acting as a general evaluation of global self-esteem (Rosenberg, 1965). The scale has been thoroughly validated as having high precision and low error, and is regarded as the gold standard in self-esteem research, with prominence especially in obesity studies due to its simplicity (Hill, 2017). This Likert-type assessment is answered on a four-point scale, in which statements dealing with general feelings of oneself are responded with “Strongly Agree” to “Strongly Disagree”. Half of the questions are scored in reverse order since they appear in a negative connotation, and a higher total score out of 30 (where strongly agreeing with positive statements or strongly disagreeing with negative statements yields 3) indicates a higher global self-esteem. The RSES evaluation is presented in Table 2.1.

Table 2.1. The Rosenberg Self-Esteem Scale Questionnaire, (Rosenberg, 1965)

#	Question	Scoring			
1	On the whole, I am satisfied with myself.	SA	A	D	SD
2*	At times, I think I am no good at all.	SA	A	D	SD
3	I feel that I have a number of good qualities.	SA	A	D	SD
4	I am able to do things as well as most other people.	SA	A	D	SD
5*	I feel I do not have much to be proud of.	SA	A	D	SD
6*	I certainly feel useless at times.	SA	A	D	SD
7	I feel that I'm a person of worth, at least on an equal plane with others.	SA	A	D	SD
8*	I wish I could have more respect for myself.	SA	A	D	SD
9*	All in all, I am inclined to feel that I am a failure.	SA	A	D	SD
10	I take a positive attitude toward myself.	SA	A	D	SD

SA= Strongly Agree; A= Agree; D= Disagree; SD= Strongly Disagree
*Indicates scoring to be done in reverse order

The other most commonly used unidimensional scale in early self-esteem research was the Self-Esteem Inventory (SEI) developed by Stanley Coopersmith in 1967, intended for young adolescents. Coopersmith defined self-esteem as the way people perceive and value themselves, specifically the extent to which someone believes themselves to be capable, significant, successful, and worthy in relevant areas of life (Coopersmith, 1967). This 50-item scale stresses the evaluation of oneself against a set of excellence criteria, rather than measuring attitudes and feelings as the RSES does. Although it asks questions related to distinct components of children's lives (parents, peers, school, personal interests), it creates an aggregate score as the sum of assets and liabilities in these domains.

2.2.1.2 Multidimensional approaches. Perceived multidimensional self-esteem has roots in the Jamesian (James, 1890) conceptualization of self-worth, which in essence was an evaluation of self-competence in particular areas viewed as important to oneself (Hill, 2017). Since there are multiple domains in which one can self-evaluate, and certain domains have more importance to each individual, when a person feels low competence in an area of high importance to them, this impacts overall self-worth (Hill, 2017). A review of self-esteem scales used in the literature between 1985-2005 indicated that over 200 unique scales have been used to assess self-esteem among children and adolescents, but only a handful of these were multidimensional in nature (Butler & Gasson, 2005). The most common multidimensional scales used among youth during this time include the Piers-Harris Self-Concept Scale (SCS) (Piers, 1969, 1984, 1996, 2002); the Tennessee Self-Concept Scale (TSCS) (Fitts, 1965, 1988, 1996); the Multidimensional Self-Concept Scale (MSCS) (Bracken, 1992); and the Self-Perception Profile for Children (SPPC) (Harter, 1985) and Adolescents (SPPA) (Harter, 1988).

In general, multidimensional scales moved to a rationalization whereby people of varying ages evaluate themselves differently in arenas of life that may be more relevant to them. For example, starting in adolescence when teenagers begin to work part-time jobs, their self-evaluation of their job-related competency becomes an increasingly important issue (Harter, 2012a). Research has shown that short and long-term changes occur, as self-esteem typically rises in late childhood, becomes significantly lower in early adolescence, then increases again in late adolescence (Radziwiłłowicz & Macias, 2014). Throughout life, people value varying areas of competency differently, and thus assessment content should therefore change with age, as different tools have been created for specific age groups. Utilizing multidimensional scales does not imply that global self-worth is irrelevant or cannot be simultaneously assessed, in fact using these tools can quantify how specific domains contribute to overall self-worth. For example, Harter has described that physical appearance self-esteem has the most significant correlation (r=0.72-0.78) with global self-worth among all age groups (Harter, 2000). Recent studies consistently administer the Rosenberg SES for global self-worth, and the Harter

SPPC/SPPA for domain-specific self-esteem in children and adolescents, which also includes a measure of global self-worth.

2.2.1.2.1 Susan Harter's self-perception profiles. Susan Harter has significantly contributed to the knowledge base around the assessment of perceived self-esteem, and has created scales for use in children, adolescents, college-aged students, and adults (Harter, 2012a, 2012b). Specific to children, Harter concluded that self-esteem is best assessed by domains relevant to parents (scholastic and behavioral self-esteem) and peers (physical, social, and athletic self-esteem). Through adolescence and adulthood, these pertinent domains expand to self-esteem in occupation, romance, and long-term relationships. Whereas previous scales such as the Piers SCS and Coopersmith SEI utilized two-choice response formats (e.g. "Like me" or "Unlike me") (Coopersmith, 1967), Harter designed her scales in a *structured alternative format,* whereby a wider range of response choices are given. This format reduces the tendency for participants to give socially desirable responses and enhances honest choices (Harter, 2012a). In the child and adolescent surveys, all questions are structured in two parts, whereby first they must decide if they are more like one of two people, then secondly choose whether the description is "Really True for Me" or "Sort of True for Me". This allows Likert scoring on a four-point scale, where 1 indicates the lowest perceived competence, and 4 indicates the highest level of adequacy.

When administered, these surveys are titled "What I am Like", and emphasize that children are to choose the descriptions with which they most identify, where the initial question wording of "Some kids are…" and "Other kids are…" legitimizes either choice by not explicitly saying "I do…" or "I don't…". As well, the surveys employ counter-balancing, whereby half of the questions are scored in the opposite direction to ensure the items are being read carefully and not arbitrarily selected by participants. In terms of reliability, in the creation of these scales, Harter describes the internal reliability as consistently and significantly high, with Cronbach's *alpha* levels between 0.71 and 0.91 for all subscales among the youth and adolescent surveys (Harter, 2012a, 2012b). As for validity, Harter indicates that in the construction of her assessments, face validity, factorial validity, convergent validity, discriminant validity, and construct validity have all been satisfactorily addressed. Harter's scales have been modified and adapted among several different populations, and the majority of validity studies for her scales indicate significantly high validity and reliability (Broc, 2014; Gümüş, 2010; Hagborg, 1993; Rose, Hands, & Larkin, 2012; Sestito, Cozzolino, Menna, Ragozini, & Sica, 2010; Winstok & Enosh, 2004).

The SPPC is made of up 36 items and assesses self-esteem in six unique domains of Global, Scholastic, Social, Athletic, Physical, and Behavioral self-competence (with six questions each) intended for children in grades 3-8. The SPPA is an extended 45-question tool, measuring nine domains of which Job, Romantic, and Close Friendship self-esteem are added (5 questions each) and is intended for use in teenagers. Once completed, the means of each domain score are calculated, with higher scores indicating higher self-esteem in that area. An updated version of Harter's manual on the development and utilization of the SPPC scale can be downloaded (Harter, 2012a, 2012b) and is found in Appendix B, however Table 2.2 summarizes the utility and exemplary characteristics of each domain.

Table 2.2. Self-Competence Domains used in SPPC and SPPA, (Harter, 2012a, 2012b)

Domain	Definition	Examples of Characteristics
Children and Adolescent Scale		
Global Self-Worth	General perception of the self, including how much one likes oneself as a person. Not a measure or summation of specific skills or competencies.	Happy with the way leading their life, generally happy with the way they are as a human.
Scholastic Competence	Perceived cognitive competence, as applied to schoolwork.	Doing well in school, figuring out answers, finishing quickly, feeling intelligent.
Social Competence	Perceived adequacy of social ability and success.	Ability to make friends, skills to meet others like you, understanding how to become popular.
Athletic Competence	Perceived ability of one's athletic prowess.	Ability to do well at sports or outdoor games.
Physical Appearance	The extent of feelings that one is good looking.	Happy with one's look, body, face, hair, etc.
Behavioral Conduct	The extent of how one likes the way they behave.	Ability to do the right thing, act how supposed to, avoid getting in trouble.
Adolescent Scale Only		
Job Competence	The extent to which they feel have job skills.	Ready to do well at part-time jobs, feels that they are doing well at current jobs.
Romantic Appeal	Perception of romantic attractiveness.	Attractive to those who they want, dating the people they would like to be, feelings of being fun or interesting on a date.
Close Friendship	Perceived ability to make close friends in which they trust	Skills of building close friendships, finding friends they can share personal thoughts and secrets with.

Source: Self-Perception Profile for Children; Adolescents (Harter, 2012a, 2012b)

2.2.2 Causes of self-esteem change. Since the creation of measurement tools allowed the quantification and comparison of self-esteem levels, in confirmation with early theorists it has been observed that self-esteem has properties of both a state and a trait (Emler, 2001). It has an average level that is relatively stable over time, but can also vary from time to time based on several factors. The stability of attitudes and self-esteem varies among individuals, as some people could endure changes over short or long periods of time, or become progressively more stable with age (Emler, 2001).

In a comprehensive review of self-esteem by Nicholas Emler (2001), the determinants of self-esteem as guided by the early theories of James and Cooley were identified. Table 2.3 summarizes these heavily studied factors having significant, moderate, and weak effects on self-esteem in youth.

Table 2.3 Factors Studied in Relation to Self-Esteem in Youth

Determinant		
Significant Impact	**Moderate Impact**	**Weak or No Impact**
Parents	Successes and Failures	Ethnicity
Genes	Rejections and Acceptances	Social Class
	Appearance	Gender

Source: The cost and causes of low self-esteem, (Emler, 2001)

Of all the factors considered by Emler's review, the largest sources of change in self-esteem are related to parental behavior and genetics. In accordance with the views of Cooley (1902), since self-concept is shaped by the appraisals of those we hold in high regard, it makes sense that parents have a significant impact on their children's self-esteem. Conclusions by Coopersmith (1967) suggest that certain parental behaviors are crucial to the development of positive self-esteem, with parental approval and acceptance/support playing a very large part (Coopersmith, 1967). Other parental characteristics including parental involvement, behavior standards, disciplinary principles, and child communication were also found to be important (Coopersmith, 1967). It has been observed that although self-esteem becomes more bearing on peer-approval in adolescence, parental influence remains significant even into adulthood (Emler, 2001). Likewise, it has been observed that failures in parenting are sources of low self-esteem. A consistent finding is that experiencing physical or sexual abuse in childhood by parents or guardians causes significant long-term damage to self-esteem (Emler, 2001). Similar factors such as parental divorce or homelessness are also associated with low self-esteem, potentially indicative of social support structures being lost. Another large influencer on self-esteem is that of genetics. In a study measuring self-esteem scores among pairs of twins, it was determined that inherited differences (genetic makeup) contributed to 30% of the variation in self-esteem (Kendler, Gardner, & Prescott, 1998). Thus, the endogenous factors related to genetic makeup contributed to a significant proportion of self-esteem, potentially determining one's baseline self-esteem as a trait.

Factors that have been studied as having a moderate impact on self-esteem include successes and failures, acceptance and rejection, and appearance. In theory, real successes should increase self-esteem and actual failures should decrease self-esteem. However, typically people's actual achievements do not perfectly match their perceived achievements, as self-esteem is only modestly influenced by actual successes and more by comparison and feedback from others. Experimental research has demonstrated that when given false feedback on performance in certain areas, self-esteem was temporarily modified accordingly (Emler, 2001). In areas where there is no mismatch between estimations of success, such as in academic settings where real scores can be observed and compared with others, research has consistently found an association between academic achievements and self-esteem (Emler, 2001). However, this association has been concluded to be relatively small, as a meta-analysis found an average correlation of r=0.18 (West, Fish, & Stevens, 1980). There are several potential reasons why self-esteem may not be directly impacted by academic success, namely that achieving low grades may not lead to people devaluing themselves overall, as people can discount these failures and attribute them to other reasons not having a bearing on self-esteem. Based upon James' (1890) idea further developed by Harter, the relationship between competence in an area and self-esteem is far stronger in areas which one finds more important, and thus those individuals that do not consider academics to be significant may not allow their self-esteem to be impacted by these failures.

In line with how successes and failures modify self-esteem, a person's experience of being accepted or rejected leads to similar effects. The most studied example of this comes from the labour market, where evidence consistently suggests that losing one's job, failing to find work, and spending time unemployed are all associated with lower self-esteem (Emler, 2001). Longitudinal studies have found that compared to employed adults, those who spend more time unemployed or have unsatisfactory employment report significantly lower self-esteem over time, with effect sizes related to the length of these stressful experiences (Prause & Dooley, 1997). Although significant, these contributors have been described as having relatively small effects, as individuals may utilize denial techniques of discounting their misfortune due to blaming employers or economic conditions, thus not allowing these rejections to impact their self-esteem. Also, other consequences of unemployment such as social isolation, loss of social support, economic stress, and loss of routine or sense of purpose could attenuate the effect of unemployment, since they may have independent relationships with lower self-esteem (Emler, 2001).

Another factor of considerable importance to self-esteem is physical appearance. This relationship is particularly high in adolescents according to research by Harter, who argues that in some groups of young people self-esteem is almost entirely dependent on appearance, with correlations reaching the range of r=0.80 (Harter, 2000). However, research has shown that this association is based on self-perceived physical appearance and not necessarily objective reality (Emler, 2001). Although the literature is mixed, studies have found that objective body measures such as body mass index were not necessarily directly related with self-esteem, but measures such as body dissatisfaction were more correlated (Emler, 2001). The effect of body size on self-esteem varies based on what is considered to be culturally acceptable. These effects are demonstrated as women place relatively more importance on slimness, leading to a slightly lower average self-esteem at all ages, with the most marked effects observed in late adolescence between the ages of fifteen and eighteen (Emler, 2001).

Other factors that have been widely studied but maintain relatively small effect sizes are that of race, social class, and sex. Although the difference is not large, a highly consistent finding is that for almost every age group, the average self-esteem of African Americans is higher than that of their Caucasian counterparts (Gray-Little & Hafdahl, 2000). The most common explanation for this relies on the cultural norms that exist across different minority groups, where approval (and thus self-esteem) is obtained from those close to them and not from society as a whole (Gray-Little & Hafdahl, 2000). Therefore, if a larger or smaller body size is considered typical among a certain culture, their self-esteem will be modified accordingly based on what they believe is acceptable. Although one can assume the same implications for members of certain social classes, the difference with this factor is that people typically believe that they can alter their social class position, which is not true for race or skin colour. Thus, if a person belongs to a low socioeconomic position, they may feel they lack the necessary skills or aptitude to move to a higher class, as social class position has been moderately linked to self-esteem in adults (Rosenberg & Pearlin, 1978). This relationship however, is non-existent among children and adolescents as Rosenberg argues that since social class is derived from parental social position, it carries no impact on the self-worth of youth as they perceive no direct responsibility for their class (Rosenberg & Pearlin, 1978). In terms of sex differences, the finding that males have higher global self-worth than females is highly consistent yet small in its effect size (Emler, 2001). A meta-analysis estimated that among 216 studies considering the relationship, the difference between the global self-worth of males and females had an effect size of 0.21 (Kling, Hyde, Showers, & Buswell, 1999). Although many explanations for this difference are postulated, the most significant influencing factor was age, whereby the largest differences between male and female self-esteem exist during late adolescence, with quite smaller effects prior to and after this time period (Emler, 2001).

2.2.3 Consequences of low self-esteem. In the same review, Emler (2001) points to several consequences of having low self-esteem in childhood and adolescence. Longitudinal studies have demonstrated that self-esteem has a causal influence on a number of behavioral patterns including: more unhappiness; symptoms of depression; teenage pregnancy; suicidal thoughts or attempts; greater unemployment and lower wages; eating disorders; peer victimization, and trouble forming close relationships. (Emler, 2001). Other studies have pointed to additional consequences in adulthood including other mental health problems such as anxiety and tobacco dependence; physical health problems such as poor cardiorespiratory health and higher waist-to-hip ratios;

greater criminal activities and incarceration; and economic problems including lower education and employment problems (Trzesniewski et al., 2006).

2.3 Obesity

2.3.1 Definition. The World Health Organization (WHO) defines obesity as a condition of abnormal or excessive accumulation of fat (adipose) tissue, to the extent that health may be impaired (WHO, 2000). Obese individuals are characterized by *android fat distribution* primarily in the abdominal wall. This is in contrast to *gynoid fat distribution* which is characterized by fat tissue distributed more evenly and peripherally around the body (WHO, 2000).

Although there is no universally agreed upon scale to classify obesity, there are several measures that have been utilized. By creating indices to measure obesity, this has allowed the identification of individuals or groups who are at increased risk of morbidity and mortality, comparison of obesity across populations, and enabled interventions to be applied and tested. Widely used physical measures include body mass index (BMI), waist circumference (WC), and waist-to-hip ratio (WHR), as well as other measurement tools related to body composition (e.g. dual-energy X-ray absorptiometry, bioelectrical impedance, skinfold thickness), fat distribution (e.g. computer tomography, ultrasound, magnetic resonance imaging), and energy intake (WHO, 2000).

BMI is a commonly used tool for weight status classification because it is a simple index distinguishing underweight, normal weight, overweight, and obesity in adults. BMI is the ratio of one’s weight to height and is calculated as body weight in kilograms divided by the square of standing height in metres ([weight, kg] / [height, m^2]).

The World Health Organization has specified BMI cut-offs based on the studied risks associated with co-morbidities and mortality at given classifications. Table 2.4 outlines the accepted BMI categorizations along with their risks of associated comorbidities in adults (WHO, 2000). Since BMI is a crude measure of obesity, it does not take into account differences in body mass from fat versus that from muscle, and thus is not a perfect measure of central adiposity. Since several race-specific associations between adiposity and health outcomes have been identified, BMI classifications do not always consider variations among different populations specific to sex, race, and body build (Chan & Woo, 2010). Therefore, it has been recommended that BMI measurements in adults should be combined with an assessment of central fat distribution to more accurately assess health risks (Chan & Woo, 2010).

Table 2.4. Adult Weight Classifications According to WHO BMI cut-offs and their Associated Risks

Body Mass Index (kg/m^2)	Classification	Risk of Co-morbidities
<18.5	Underweight	Low*
18.5-24.9	Normal Weight	Average
25.0-29.9	Overweight *(Preobese)*	Increased
30.0-34.9	Obese Class I	Moderate
35.0-39.9	Obese Class II	Severe
≥40	Obese Class III	Very Severe

Source: Obesity: Preventing and Managing the Global Epidemic. (WHO, 2000)
*Increased risk of other clinical problems exist

Several studies have compared different anthropometric scales for classifying obesity in relation to associated health risks, and waist-to-hip ratio and waist circumference have both been observed as having significant correlations with abdominal fat distribution and obesity-related comorbidities (Chan & Woo, 2010). The WHR (ratio of waist circumference to hip circumference) has been shown to be a useful predictor of health risks based on the cut-offs of 1.0 and 0.85 in men and women, respectively. However, due to the challenges of routinely measuring hip circumference with accuracy and the fact that WHR can remain constant even with increased or decreased body mass, waist circumference is often preferred (Chan & Woo, 2010). Waist circumference is measured at the midpoint of the lower border of the rib cage and the iliac crest, and is suggested to be a more useful health assessment measure of obesity due to its strong correlation with BMI, WHR, total body fat, and intra-abdominal fat mass. Although racial variations exist, general cut-points for increased/ substantially increased metabolic risks are defined at 94cm/102cm for males and 80cm/88cm for females, respectively. It has been demonstrated that waist circumference is more strongly related to cardio-metabolic outcomes such as cardiovascular diseases (CVD), diabetes mellitus, and mortality than BMI (Chan & Woo, 2010; WHO, 2000).

2.3.2 Definition in children and adolescents. In adults, BMI cut-offs are the most widely recognized classifications of obesity since international growth charts have been aggregated under the assumption that height remains relatively constant throughout adulthood, and thus changes in weight (i.e. central fat gain) lead to greater body mass index. However, since body composition and height change drastically throughout childhood and adolescence at different rates, defining obesity in these populations using BMI has been a challenge due to its substantial changes with age. This is characterized by a steep rise in BMI during infancy, a fall during preschool years, and a rise again during adolescence and early adulthood. (WHO, 2000).

In 2000, Cole and colleagues of the International Obesity Taskforce published a set of age and sex-specific obesity BMI cut-offs for children ages 2-18 (Cole, Bellizzi, Flegal, & Dietz, 2000). By using growth and BMI data from large cross-sectional surveys from six regions including Brazil, Great Britain, Hong Kong, the Netherlands, Singapore, and the United States, they were able to use the adult BMI cut-points of 25 and 30 kg/m^2 for overweight and obese, respectively to extrapolate backwards and create specific centile curves and cut-points for each sex-specific age. Since a heterogeneous mix of regions with different characteristics were used in the averages, the new standard definitions are a less arbitrary way to define and compare youth obesity data across different populations. Overall, children with a BMI in the 85^{th}-<95^{th} percentile are considered overweight, and those at or above the 95^{th} BMI percentile are considered obese, with the accepted classifications found below in Table 2.5. Limitations of these definitions for children are that they may not be adequately representative of non-Western populations, and it is unclear whether BMIs above the adult-linked cut-points are related to similar health consequences in children (WHO, 2000).

In 2006 and 2007, the WHO released new growth standard charts for infants/ young children and children/ adolescents, respectively (de Onis et al., 2007; WHO, 2006) building off of the previous 1977 WHO/ National Center for Health Statistics (NCHS) growth charts (WHO, 1995). They created height-for-age, weight-for-age, and BMI-for-age curves from the 1^{st} to the 99^{th} percentile, also generating z-score curves. The infant and young children charts for age 0-5 were created using samples of healthy children from around the world who followed internationally recognized health recommendations such as breast-feeding. The adolescent growth charts were compiled in a similar way for ages 5-19, once again extrapolated backwards from the adult-linked obesity cut-offs (de Onis et al., 2007).

Table 2.5. Youth Weight Classifications According to WHO BMI Percentile Cut-offs

BMI Percentile	Classification
<5^{th}	Underweight
5^{th}- <85^{th}	Normal Weight
85^{th}- <95^{th}	Overweight
≥95^{th}	Obese

Source: Cole (2000)

2.3.3 Effects of obesity.

2.3.3.1 Physical effects. An extensive amount of research has examined the physical health effects of overweight and obesity. A systematic review and meta-analysis by Guh and colleagues (2009) considered almost 90 high quality prospective cohort studies and identified 18 significant co-morbidities for overweight and obesity in adults based on body mass index and waist circumference classifications. A wide range of illnesses have been identified as a result of abdominal fatness and excess weight, including cardio-metabolic diseases, cancers, and several others including asthma, gallbladder disease, osteoarthritis, and chronic back pain (Guh et al., 2009).

Type 2 diabetes had the strongest association with overweight and obesity in both males and females. Based on BMI classifications described earlier, the pooled relative risk (95% CI) for those overweight and obese compared to those of normal weight was 2.40 (2.12–2.72) and 6.74 (5.55–8.19) in males, and 3.92 (3.10–4.97) and 12.41 (9.03–17.06) in females, respectively (Guh et al., 2009).

In the meta-analysis, significant associations were observed between overweight/ obesity and hypertension, stroke, coronary artery disease, ischemic heart disease, congestive heart failure, dyslipidemia, and pulmonary embolism among both sexes. In the majority of these comorbidities, waist circumference was a better predictor than body mass index (Guh et al., 2009).

Specific to cancer, Guh and colleagues found significantly increased risks for breast, endometrial, and ovarian cancer in women; and kidney, colorectal, and pancreatic cancers among males and females (Guh et al., 2009). The meta-analysis estimated the pooled relative risk of various cancers in overweight and obese samples ranged between 1.05–2.29 in males and 1.13−3.22 in females, respectively (Chan & Woo, 2010). The systematic review found that for all significant cancer associations, BMI was a better risk predictor than waist circumference. The 2007 World Cancer Research Fund/ American Institute for Cancer Research expert report on obesity and cancer also concluded that overweight and obesity related to abdominal fatness increased the risk of cancers of the esophagus, pancreas, colon and rectum, breast (postmenopausal), endometrium, and kidney (AICR, 2007). The approximate risks of physical health problems associated with obesity are summarized below in Table 2.6.

Other illnesses that have been documented as a result of excess weight include respiratory diseases, chronic kidney diseases, musculoskeletal disorders, gastrointestinal and hepatic disorders, lower physical functioning, and psychological disorders (Chan & Woo, 2010).

Table 2.6. The Estimated Risk of Comorbidities Related to Obesity in Adults

Relative Risk 1-2	Relative Risk 2-3	Relative Risk >3
Cancer	Coronary heart disease	Type II Diabetes
Reproductive hormone abnormalities	Hypertension	Gallbladder disease
Polycystic ovary syndrome	Osteoarthritis	Dyslipidemia
Impaired fertility	Hyperuricemia and gout	Insulin resistance
Low back pain		Breathlessness
Increased risk of anesthesia complications		Sleep apnea
Fetal defects (material obesity)		

Source: World Cancer Research Fund/American Institute for Cancer Research (2007)

2.3.3.2 Psychosocial effects. Aside to the indicated physical comorbidities of overweight and obesity, the literature has demonstrated considerable psychosocial effects. Those youth who are overweight or obese are more likely to experience social stigmatization, negative interactions, and peer teasing and victimization (Lowry, Sallinen, & Janicke, 2007; Sutter, Nishina, & Adams, 2015). There is a heavy psychosocial toll as a result of this social isolation, leading obese children to have higher rates of body dissatisfaction, anxiety, and mood disorders such as depression and bipolar disorder (Lee, Cheah, Chang, & Siti Raudzah, 2012). Since higher rates of feeling sadness, loneliness, and anxiety are found in obese youth, this can subsequently lead to high risk-behaviours such as eating disorders and suicidal tendencies in the future (Strauss, 2000). As well, studies among obese children consistently find lower reported quality of life and self-esteem scores compared to their normal weight peers.

2.4 Self-Esteem and Obesity

2.4.1 Relationship in children and adolescents. Three notable reviews of the literature have been completed on this topic specifically related to children and adolescents: French et al. (1995), Lowry et al. (2007), and Griffiths et al. (2010). The following summarizes these reviews as well as the pertinent up to date literature on this relationship.

The first review by French and colleagues (1995) examined 35 studies related to self-esteem and obesity in children and adolescents published from 1967 to 1995. They distinguished studies based on age range (3-7, 7-12, 13-18 years) as well as the study (prospective, treatment, cross-sectional) methodology (French, Story, & Perry, 1995).

The majority of the examined studies were cross-sectional in nature, and the review found that 13 of the 25 cross-sectional analyses reported significantly lower self-esteem among obese youth compared to non-obese. The most consistent associations were found among the adolescent group aged 13-18, with inconsistent and less significant findings in younger children. Among the significant findings, it was most often established that an inverse relationship exists between self-esteem and overweight/ obesity and that self-esteem scores were significantly lower in higher weight compared to normal weight youth. In one of the earliest studies, Coopersmith et al. (1967) demonstrated that clinician-rated "good" body physique was positively related to high self-esteem among grade school males (Coopersmith, 1967). Another study examining males and females in grades 3-11 found that self-esteem (Piers-Harris scale) was significantly lower in the obese compared to the non-obese group, when using the 75^{th} weight percentile as the cut-off for obesity (Sallade, 1973). Martin and colleagues used the Rosenberg scale as their measure of self-esteem and found that among females aged 12-16, there was an inverse relationship between relative weight categories and self-esteem, as scores decreased with increasing weight status (Martin et al., 1988). Several studies found no significant results, or significant associations only for specific sexes, races, or age groups.

Among the eight treatment studies examined by French et al. (1995), six of them found that participation in weight loss programs improved self-esteem. A study by Foster et al. found that with no baseline difference in self-esteem, those who were obese participating in a weight management program had significantly higher self-esteem increases than normal weight untreated controls (Foster, Wadden, & Brownell, 1985). Another effort by Sherman and colleagues (1992) concluded that self-esteem (Rosenberg & Simmons scale) significantly increased among a sample of obese grade four to six students during an intervention program (Sherman, Alexander, Gomez, Kim, & Marole, 1992). An interesting finding from O'Brien pointed to high levels of self-esteem at baseline being related to decreased body fatness (ponderosity index) after 1-3 years in black children who were obese at baseline then normal weight at follow-up (O'Brien, Smith, Bush, & Peleg, 1990). This potentially indicates a flipped causal pathway whereby feeling good about oneself with high self-esteem may contribute to the ability to improve obesity measures. Although most studies did find significant associations between participation in an obesity intervention program and increased self-esteem, most did not solely attribute the relationship to changes in weight, and follow-up times and measurement tools varied among studies.

At the time, the literature addressing the causal relationship between obesity and self-esteem in children was very limited. However, of the three longitudinal studies examined, two had some significant results relating obesity to self-esteem. In a study including 3-6 year old white children, Klesges et al., (1992) found that as body fat increased, physical appearance self-esteem (Harter Scale) decreased in boys but not girls after a one and two (but not three) year follow-up (Klesges et al., 1992). French et al. (1996) conducted a study with 1,278 adolescents in grades seven to nine and followed this cohort for three years using the Harter Scale to assess all domains of self-esteem and BMI to assess obesity (French, Perry, Leon, & Fulkerson, 1996). While their baseline cross-sectional analysis revealed significant inverse associations between BMI and various domains of self-esteem, their prospective analyses showed that physical appearance, social acceptance, and behavioral conduct self-esteem at baseline were inversely associated with BMI changes after three years and only in females. The relationship was not observed among males, and the associations were modest, thus indicating that low self-esteem may not always predict increased obesity over time (French et al., 1996). The third longitudinal analysis followed over 10,000 adolescents at baseline for seven years, and did not find significant changes at follow-up in the self-esteem (Rosenberg Scale) between those who were obese (>95^{th} BMI percentile) and non-obese at baseline (Gortmaker, Must, Perrin, Sobol, & Dietz, 1993).

Although the literature up until 1995 was limited in terms of volume of studies and consistent methodology, it is apparent that a modest cross-sectional inverse relationship exists between obesity and global self-worth in youth, more specifically in adolescents aged 13-18. Treatment studies also generally showed increases in self-esteem during weight intervention among obese youth, however not necessarily attributable to weight changes alone. The prospective studies were conflicting in their results, as one study found no significance when the forward pathway of obesity and self-esteem was examined, under stringent cut-off criteria. The other two studies measured self-esteem at baseline to predict body composition changes, and showed modest sex-specific effects, suggesting the causal pathway is still unclear.

The largely inconsistent results of French's (1995) literature review may be attributed to several features of the included studies. Firstly, the sample sizes used were generally small, as approximately half of the examined papers included fewer than 100 subjects, with ten having less than 50, and six having no appropriate control groups. As well, only a few studies included both children and adolescents evaluated using the same methodology, which may account for the age-related differences observed. Another key factor are the inconsistent definitions whereby researchers defined self-esteem and obesity. Over ten different scales were used to assess self-esteem and body-esteem, and over twelve different measures were used to define body fatness. These included crude BMI and BMI percentiles (ranging from 67^{th}-95^{th} to define overweight/ obesity), ponderosity (weight/height^3), triceps and subscapular skinfold thickness, weight, relative weight, percent overweight, and clinical examiner or peer ratings. Very importantly, most of the examined literature failed to account for the effects of socio-cultural variables such as sex and race, and other factors that may impact the relationship.

French and colleagues (1995) identified several areas where future research in the field should be directed. Their recommendations included examining the effects of familial or cultural factors to determine which groups are at greatest risk of low self-esteem due to obesity; further exploring self-esteem among treatment studies and assessing whether changes are specifically related to weight loss; and emphasized prospective examination of self-esteem and obesity to determine the causal relationship, age of onset, duration, and severity (French et al., 1995).

Based on the recommendations identified by French in 1995, Lowry and colleagues published a 2007 comprehensive review of only interventional studies assessing the impact of weight management programs on child and adolescent self-esteem (Lowry et al., 2007). They utilized 21 pediatric weight management studies that reported data on self-esteem, including those previously reviewed by French et al. and thirteen additional studies up until 2006. For each study, they noted both the self-esteem and weight change results post-intervention, as well as documented any parental participation. It was found that the large majority of intervention studies (18 of 21) reported some evidence of increased self-esteem (global or by domain) from pre to post-treatment, with two reporting no changes, and one reporting decreased self-esteem after intervention (Lowry et al., 2007).

The characteristics of more up-to-date studies were evidently superior to those of the past, as some of the issues French et al. (1995) brought up had been appropriately addressed. Half of the intervention studies used the same self-esteem (Harter Scale) measurement tool, with 25% using the Piers-Harris scale. As well, most of the studies used tools which were multidimensional rather than measuring global self-worth alone. Nine of the twenty-one papers included a mixed age-range of child and adolescent participants from 7-18 years old, allowing comparisons across age groups under the same criteria.

A 10-month treatment program among 38 males and females aged 10-17 in an inpatient setting including parental education led to significant increases in self-esteem in the Harter domains of physical appearance, athletic competence, and social competence post-intervention, along with significant decreases in BMI compared to the control group

(Braet, Tanghe, Bode, Franckx, & Winckel, 2003). Another study conducted in a weight loss camp saw adolescents experiencing increased global self-worth, athletic, and physical appearance self-esteem along with significant BMI reductions and weight loss compared to control groups (Walker, Gately, Bewick, & Hill, 2003). Global self-worth was measured most often and found to show improvements after intervention, but four studies reported significant improvements in specific self-esteem components without changes in global self-worth (Lowry et al., 2007). Contrary to what was found in the first review of the literature, Lowry's (2007) results suggest that younger children had consistently positive changes in self-esteem, whereas the adolescent and mixed samples had more variability in their results.

Some methodological issues were not improved in the more recent literature. Sample sizes ranged from 11 to 634 participants, a varying amount of participant study sites were used, and different settings (inpatient, outpatient, camp, school) were utilized among studies. After post-treatment measurement, extended follow-up periods for self-esteem changes were limited and only documented in six studies. As well, the majority of studies consisted of predominantly Caucasian participants, and among those that reported race, differences due to this were unclear or not examined at all.

Overall, the examined intervention studies suggest uniformly positive effects on self-esteem due to weight loss programs across different settings and ages. Factors that contributed to significant improvements in self-esteem included actual weight change, parental inclusion/ education, and presence of a peer group setting. The research suggests that specific self-esteem domains such as physical appearance may be influenced more prominently, which may lead to subsequent improvements in global self-esteem. (Lowry et al., 2007). Although these multi-faceted programs consistently led to self-esteem improvements, the relationship with weight change independently had mixed results. Although some documented the association, many studies found no relationship between decreases in weight and improved self-esteem, and in a few cases self-esteem improved even in the absence of any weight change, potentially due to the other factors involved.

The authors recommended that better designed studies with stronger control groups utilizing multidimensional self-esteem scales are needed to further confirm and expand the mixed findings. Due to the complexity of the causal pathway, more emphasis should be placed on examining its direction, the potential mediators of self-esteem change, and measuring the impact of important psychosocial and demographic risk factors. Since the interventions were widely variable in their methodologies and analytic strategies, more uniform methodological approaches should be considered for this topic, with more information such as sample characteristics and detailed treatment components reported. Lowry and colleagues also indicated the need for longer-term follow-up data, specifically to evaluate related factors such as weight re-gain on long-term self-esteem (Lowry et al., 2007).

A systematic review on the topic was published in 2010 by Griffiths et al. and examined 42 studies on obesity and quality of life (17 specific to self-esteem) published since 1994. This review built on existing reviews but was restricted only to studies that used validated multidimensional measures of self-esteem, a consistent definition of pediatric obesity, as well as those incorporating the effects of age, sex, and race among cross-sectional, interventional, and longitudinal studies (Griffiths et al., 2010). The most consistent finding in this review was that among studies measuring global self-worth, two-thirds of them found significantly lower scores in obese subjects compared to normal weight children. Similarly, the sub-domains of physical appearance, athletic, and social self-esteem were found to be lower in obese subjects, with little evidence demonstrating an effect on scholastic (cognitive) competence. The review did not firmly differentiate this association in children versus adolescents as previous findings did, since the relationship was found consistently throughout all examined age groups.

In a large cross-sectional study of Australian children aged 8-14, Franklin and colleagues (2006) measured the likelihood of low self-esteem (mean score ≤2) in each of the Harter SPPC domains comparing those in each weight group as defined by the CDC 2000 cut-offs. It was found that obese children were 2-4 times more likely to have significantly lower global self-worth along with athletic and physical self-esteem compared to their normal weight peers. Subsequently, girls scored lower in each of these domains than boys and also had significantly lower social acceptance self-esteem. (Franklin, Denyer, Steinbeck, Caterson, & Hill, 2006). A prospective study among 1,520 US children 9-10 years of age at baseline were followed up at two and four years measuring the global and scholastic sub-scales of the SPPC. Compared to their non-obese peers, obese (>95th BMI percentile) boys, and obese white and Hispanic girls had significantly lower global self-esteem after four years, with no changes in scholastic competence seen among any group. The decrease in females was more pronounced than that in males, and racial differences were present as the change was not observed in African American girls. Compared to those whose self-esteem remained unchanged or increased, obese children with lower self-esteem experienced higher rates of sadness, loneliness, nervousness, and likelihood of tobacco smoking and alcohol drinking

(Strauss, 2000). Due to limited evidence, generalized demographic conclusions could not be made, however some significant associations were observed (Franklin et al., 2006; Strauss, 2000). Although the majority of intervention studies in Griffiths' (2010) review found that weight loss and increased global self-esteem occurred over the intervention period, among the five studies that examined the relationship of these factors, only one found a significant independent correlation between weight loss and increased self-esteem. This may be due to methodological differences such as sample size or measurement timing, or point to the potential benefit of organized support programs or physical activity on self-esteem, even without apparent weight loss (Griffiths et al., 2010). A camp-based study in the United Kingdom examining the effects of a multidisciplinary weight-management program on 58 obese adolescents found significantly increased global, athletic, and physical self-esteem compared to normal weight controls. Both weight and BMI were reduced during the intervention, and these changes were significantly associated with global self-worth in the obese subjects (Walker et al., 2003).

The authors point to similar areas in the field requiring further attention (Griffiths et al., 2010). Firstly, sex and race along with other potential covariates need additional research, as protective factors could be identified that make certain youth more resilient to the consequences of obesity. Secondly, further longitudinal research is needed to clarify the direction of the relationship and potential changes that occur with weight re-gain, as still few prospective analyses exist with extended follow-ups. Finally, additional research is needed to examine possible interventions that may have a positive influence on self-esteem, even in the absence of weight loss such as peer-structured or parental intervention programs. It is clear that obesity impairs self-esteem in youth, specifically related to global, athletic, physical, and social domains, thus targeted interventions may be aimed at these areas to improve quality of life.

The following summary highlights the methodology and results of 19 studies not examined by previous reviews, published from 2004-2016, split into cross-sectional, prospective, and experimental designs. Table 2.7 displays a summary of this research arranged by study design and year of publication, outlining sample characteristics, self-esteem and weight categorizations, as well as significant findings. Some studies which utilized multiple methodologies are present in more than one section of the table.

2.4.1.1 Cross-sectional studies. Of the 19 studies reviewed, 14 (74%) of them included cross-sectional analytic methods to assess the relationship between obesity and self-esteem in youth. Of these, sample sizes ranged from *n*=72 to *n*=4,945, and all but one included both males and females in their sample, with proportions ranging from 42%-55% male. In terms of age group, about 60% of the cross-sectional studies were among children (7-12), 20% were among adolescents (13-21), and 20% consisted of a mixed sample. Only roughly 40% of the publications reported race or geographic information, of which studies primarily examined Caucasian, Chinese, or African American samples, with few reporting a balance of races. Studies differed with respect to the self-esteem measure they utilized, where four used the RSES, three used the SPPC/ SPPA, and three used internal or modified scales. To assess weight status, all studies used BMI in some form with the majority (70%) using BMI cut-offs (CDC or WHO), and others using crude BMI, international BMI z-scores, or BMI percentiles.

Significant results were found in 11 of 14 cross-sectional studies, and the primary finding was that an inverse relationship exists, as compared to those of normal weight, overweight and obese youth had significantly lower self-esteem scores and had greater risk of low self-esteem. For those studies utilizing unidimensional self-esteem measures such as the RSES, average global self-worth scores were found to be significantly lower in the higher weight groups. Radziwillowicz and Macias (2014) observed that compared to normal weight (BMI 18.5-24.9), Polish adolescents that were overweight/ obese (BMI≥25) had significantly lower ($p<0.01$) Rosenberg global self-esteem scores and were more likely to be classified as having low or average self-esteem (Radziwiłłowicz & Macias, 2014). Abdollahi et al. (2016) found the same relationship in Iranian youth and adolescents (15-21) with overweight and obese individuals having significantly lower self-esteem scores ($p<0.001$) than normal weight participants (Abdollahi, Talib, Mobarakeh, Momtaz, & Mobarake, 2016). A Chinese study by Zhang and colleagues (2016) grouped children (9-12) into low/average/high self-esteem groups based on being ±1 SD above or below the RSES mean and had the same findings as well. Subsequently, they found a negative correlation between self-esteem scores and BMI (r=-0.12, $p<0.05$), and of those in the low self-esteem group, there was a significantly higher proportion ($p<0.05$) of obese compared to normal weight children (Zhang et al., 2016). Their multivariate logistic regression model estimated that being overweight or obese compared to normal weight increased the odds of having low self-esteem by 2.60 times (95% CI: 1.71-3.95) and 3.74 times (95% CI: 2.25-6.22), respectively (Zhang et al., 2016). Taylor et al. also found this relationship in Australian children with a significant negative correlation (r=-0.19, $p<0.05$) between international BMI z-score and global self-worth

(Taylor, Wilson, Slater, & Mohr, 2012). A large Canadian cross-sectional study of almost 5,000 participants aged 10-11 found that increases in BMI were independently associated with significant decreases ($p<0.05$) in self-esteem scores, and children classified as obese were 1.44 times more likely than normal weight children (Adjusted-OR=1.44; 95% CI: 1.12, 1.84) to report low (<15th percentile) self-esteem, but a significant difference was not found in the normal weight to overweight comparison (Wang & Veugelers, 2008). Witherspoon's US study among African American children and adolescents (11-16) used Rosenberg scale z-scores and found that the obese group significantly differed from the normal and overweight groups, but like in Wang's study, the difference was not present comparing normal weight to overweight (Witherspoon, Latta, Wang, & Black, 2013).

Among studies utilizing multidimensional outcomes, the domains most often impacted by higher weight status were physical appearance and athletic self-esteem. Among 131 Australian fifth and sixth graders, Southall and colleagues observed that compared to non-overweight children, those who were overweight/ obese had significantly lower ($p=0.0017$) athletic self-esteem (SPPC), with a significant correlation between athletic competence and overweight status present (Southall, Okely, & Steele, 2004). A similar relationship was found in a racially diverse sample of third to fifth graders from the United States where BMI was a significant negative predictor ($p<0.05$) of physical appearance self-esteem measured using the Marsh Self-Description Questionnaire (SDQ) I (Fedewa, Toland, Usher, & Li, 2016). Danielson et al's (2012) large cross-sectional analysis among over 4,000 Norwegian children found significantly lower mean scores ($p<0.001$) in the scholastic, social, athletic, and physical appearance self-esteem domains (SPPC) in the overweight/ obese sample as well as a significantly higher proportion ($p<0.001$) of low self-esteem subjects (defined by mean scores ≤ 2) in that group (Danielsen et al., 2012). The domains of athletic and physical appearance were most impaired by being overweight or obese, as they demonstrated *Cohen's d* effect sizes of 0.59 and 0.68, respectively (Danielsen et al., 2012). Jennifer O'Dea's (2006) study among Australian adolescent females compared all nine Harter SPPA domains among low and high (>75th percentile) BMI participants, and found significantly lower mean scores for physical appearance ($p<0.01$), romantic appeal ($p<0.05$), job competence ($p<0.05$), and global self-worth ($p<0.001$) (O'Dea, 2006).

The most common covariates of the relationship found in cross-sectional studies were the effects of sex, race, and age. On average, self-esteem scores in global and specific sub-domains were seen to be slightly lower for females, however the majority of studies which considered this factor found no significant difference between the scores of males and females. Three of these studies did find significant sex-related differences between self-esteem and obesity. Measuring global self-worth, Abdollahi et al. (2016) found that females had significantly lower ($p<0.05$) scores than males. Nowicka and colleagues found that females had significantly lower internally scaled global ($p<0.05$), physical ($p<0.01$), and psychological ($p<0.01$) self-esteem scores (Nowicka et al., 2009). And Fedewa, utilizing the Self-Description Questionnaire found females had significantly lower eating self-competence but higher exercise self-competence (Fedewa et al., 2016). The latter two studies also observed significant effects from relative age, as Nowicka et al. (2009) found that their oldest age group in late adolescence (up to 19) had the lowest scores, with Fedewa et al.'s (2016) oldest age group (up to 11) having the highest scores. This difference is explicable since the studies used completely different age groups, and long-term changes in self-esteem occur throughout youth. The US-based study by Fedewa and colleagues (2016) also was the only cross-sectional study to report race as a significant factor. They found that African American children reported higher overall self-esteem scores than Caucasian or Hispanic children, which has also been found in past literature (Fedewa et al., 2016). Other covariates found to be significant in one or more cross-sectional studies include socioeconomic status, physical activity level, school performance, bullying, disturbed eating, achievement motivation (perseverance level, time perception, future-oriented perspective, self-confidence), body shape, and parenting style (Danielsen et al., 2012; Radziwiłłowicz & Macias, 2014; Wang & Veugelers, 2008; Zhang et al., 2016)

2.4.1.2 Prospective studies. Three prospective cohort studies were examined with sample sizes ranging from n=80 to n=2,879, all of which included adolescents ages 10 and above (O'Dea, 2006; Sutter et al., 2015; Wang et al., 2009). All of the studies used BMI cut-offs to distinguish overweight and obesity, and two of them used the Harter Scale and accounted for sex and race. In general, all three studies found a significant longitudinal relationship between BMI and one or more self-esteem domains. Aside from the cross-sectional results mentioned above, Jennifer O'Dea's three-year prospective analysis among high school girls revealed that although higher BMI girls had consistently lower self-esteem scores at each time-point, the domains of physical appearance and close friendship self-esteem became significantly poorer ($p<0.05$) over time in the higher BMI group (O'Dea, 2006).

Using the Canadian National Longitudinal Survey of Children and Youth, Wang and colleagues analyzed almost 3,000 Canadian youth aged 10-11 at baseline who were followed-up at two and four years to examine if excess weight predicts low self-esteem. Aside from their cross-sectional analysis indicating overweight/obese children had almost twice the odds of low self-esteem (Adjusted-OR=1.84; 95% CI: 1.01, 3.47), their longitudinal analysis accounting for baseline self-esteem and other covariates including sex and physical activity found that baseline weight status was independently associated with self-esteem during follow-up (Wang et al., 2009). Specifically, after four years those who were obese at baseline had 1.82 times the odds of having low self-esteem compared to normal weight children (Adjusted-OR=1.82; 95% CI: 1.01, 3.78). This study was able to demonstrate a causal relationship where childhood obesity precedes low self-esteem, as their ancillary analysis investigating the reverse relationship using baseline self-esteem and follow-up body mass was not significant (Wang et al., 2009).

A 2015 prospective study conducted by Sutter et al. (2015) examining 236 youth aged 10-16 created BMI z-scores based on the CDC growth charts, and measured global self-worth using the Harter Scale. After re-measuring six months later, it was found that for white youth, BMI population z-scores significantly predicted ($p<0.05$) changes in global self-worth, and notably this relationship was not observed among the African American youth in the sample (Sutter et al., 2015).

These longitudinal analyses all demonstrated a pathway between higher body mass at baseline resulting in lower levels of self-esteem over time. They were strong in their methodology of using large samples and included several relevant covariates such as age, sex, and race. Only Wang's (2009) study found a significant impact from sex, as being male significantly predicted higher (internally-scaled) self-esteem. Their study also pointed to higher physical activity and higher baseline self-esteem as significant predictors at the four-year follow-up. Sutter (2015) concluded that body dissatisfaction and peer victimization were mediating factors in the relationship between weight and global self-worth, but body dissatisfaction was only significant among black youth. These studies also accounted for factors that were non-significant including race, school performance, parental education, household income, and anxiety/ depression.

2.4.1.3 Treatment studies. Of the nineteen studies reviewed, only two were classified as being treatment studies by nature, and their results were somewhat conflicting. Aldaqal and colleagues (2013) compared the weight and self-esteem of 32 severely obese (BMI >40kg/m^2) adolescents in Saudi Arabia undergoing laparoscopic sleeve gastrectomy to 32 matched controls not undergoing bariatric weight-loss surgery. At baseline, they observed that the severely obese group had significantly lower RSES scores and significantly higher BMI z-scores ($p<0.001$) than the control group (Aldaqal & Sehlo, 2013). After following-up with the treatment group one year post-surgery, they found a significant increase in self-esteem and a significant decrease in BMI from their baseline values. Their explanatory regression model pointed to the loss of weight and decreased BMI z-scores as significant predictors for the improvement in self-esteem among the treatment subjects (Aldaqal & Sehlo, 2013). A South African RCT among 1,000 fourth grade students using school and curriculum-based healthy lifestyle and nutritional tools found that after a two-year follow-up, there was a significant difference ($p<0.05$) in the nutritional self-esteem (internally assessed) of those in the treatment versus the control group (de Villiers et al., 2016). However, no differences were observed at the one-year follow-up, and changes in nutritional behavior and BMI weight categories were also not seen at any time point between groups (de Villiers et al., 2016). Overall, these treatment studies did improve specific self-esteem domains among their subjects, however the direct relationship with weight loss has not been consistently proven.

Table 2.7. Summary of Recent Studies Examining Self-esteem and Obesity in Children and Adolescents

Study (Authors, Year, Location)	**Study Sample**	**Self-Esteem Measure**	**Obesity Measure**	**Results**
Cross-Sectional Studies				
Southall et al, 2004 Australia	N= 131 53.4% M Grade: 5,6 Ethnicity: N/R	Harter SPPC (Physical)	BMI cut-offs	Compared to NW children, OW/OB children had significantly lower perceived physical appearance self-esteem scores.
O'Dea, JA, 2006 Australia	N= 80 F Baseline Age: 13 Ethnicity: 85% Caucasian, 10% Asian, 5% other	Harter SPPA (all domains)	BMI >75th percentile	Higher BMI females had significantly lower Physical Appearance, Romantic Appeal, Job Competence, Global Self-Worth scores than Lower BMI group.
Nowicka et al., 2008 Sweden	N= 107 46.7% M 100% OB Age: 8-19 Ethnicity: N/R	Internal	BMI z-scores	BMI z-score not a significant contributor to self-esteem scores. Older age groups and females had consistently lower scores.
Wang et al, 2008 Canada	N= 4945 49% M 33% OW/OB Age: 10-11 65.5% urban, 34.5% rural	Internal	BMI; BMI cut-offs	Increases in BMI were associated with decreases in self-esteem. Obese students were 1.44 times more likely to have low SE than NW students. Socioeconomics, physical activity, and school performance were relevant covariates.
Wang et al, 2009 Canada	N= 2879 50.3% M Age: 10-11 80.7% urban, 19.4% rural	Internal	BMI cut-offs	OW/OB children had higher prevalence of low self-esteem. Obese children had almost 2X the odds of low self-esteem at baseline.
Danielsen et al., 2012	N= 4167 13% OW/OB	Harter SPPC (4 domains)	BMI cut-offs	OW/OB children had significantly lower self-esteem than NW in 4 SPPC domains. Athletic competence and physical

Norway	47.2% M Age: 10-13 Ethnicity: N/R			appearance self-esteem were most impaired. Bullying and disturbed eating also related to low scores.
Lee at al., 2012 Malaysia	N= 311 32.8% OW/OB 45.3% M Age: 11-13 Ethnicity: 50.8% Chinese, 25.3% Sarawak, 23.4% Malay, 0.5% Indian	Lawrence SEQ	BMI cut-offs	No significant associations between weight status and self-esteem. No significant sex differences.
Taylor et al., 2012 Australia	N= 233 23% OW/OB 47.2% M Age: 7-11 Ethnicity: N/R	SDQ; Marsh, Craven, & Debus (1991)	BMI z-scores	Larger BMI negatively associated with self-esteem and positively associated with child body dissatisfaction. Parental responsiveness was positively associated with self-esteem. No sex or age effect.
Witherspoon et al., 2013 United States	N= 235 37% OW/OB 50% M Age: 11-16 Ethnicity: 97% African American	Rosenberg SES	BMI cut-offs	Compared to NW and OW, OB adolescents had significantly lower self-esteem z-scores. No SE difference existed between sexes, however body esteem was significantly lower in females.
Radziwillowicz & Macias, 2014 Poland	N=72 50% OW/OB 50% M Age: 14-21 Ethnicity: N/R	Rosenberg SES	BMI cut-offs	Compared to NW, OW/OB adolescents had significantly lower SE. No age or sex differences were observed.
Olaya-Contreras et al., 2015 Colombia	N=678 23% OW/OB 54.9% M Age: 10-14 Ethnicity: N/R	Internal (PA)	BMI cut-offs	No difference in SE scores among NW/OW/OB groups. SE was related to # days being physically active, and # days active was different among BMI categories.

Abdollahi, 2016 Iran	N=678 25.6% OW/OB 52.9% M Age: 15-21 Ethnicity: N/R	Rosenberg SES	BMI cut-offs	Compared to NW, OW/OB has significantly lower SE. Females had significantly lower SE. SE related to social anxiety.
Fedewa et al., 2016 United States	N=109 % OW/OB 42.2% M Grade: 3-5 Ethnicity: 37.6% African American, 33% Caucasian, 29.4% Hispanic	SDQ1: (Physical, Social, General) Bandura: (Eating, Exercise)	BMI	BMI only significantly predicted physical self-esteem. Blacks had higher self-concept than whites and Hispanics. Older students had domain-specific higher scores than younger. Sex had domain-specific effects.
Zhang et al., 2016 China	N=1410 23.1% OW/OB 53.1% M Age: 9-12 Ethnicity: N/R	Rosenberg SES	BMI cut-offs	OW and OB students had significantly lower SE scores. Among the low SE group, there was a significantly higher proportion of OB compared to NW. OB had 3.74x odds of low SE.
Prospective Studies				
O'Dea, JA, 2006 Australia	N= 80 F Baseline Age: 13 Follow-up: 3 yrs. Ethnicity: 85% Caucasian, 10% Asian, 5% other	Harter SPPA (all domains)	BMI >75^{th} percentile	Significantly lower domain scores at each time point for higher vs lower BMI. Physical Appearance and Close Friendship scores significantly decrease over time compared to lower BMI group.
Wang et al, 2009 Canada	N= 2879 50.3% M Baseline Age: 10-11 Follow-up: 2/4 yrs. 80.7% urban, 19.4% rural Ethnicity: N/R	Internal	BMI cut-offs	Obese children at baseline had almost 2X the odds of low self-esteem four years later, compared with children of normal body weight. Sex and PA were significant covariates.

Sutter et al., 2015 United States	N= 236 32% M Baseline Age: 10-16 Follow-up: 6 mos. Ethnicity: 57% African American, 36% Caucasian, 7% other	Harter SPPC/SPPA (Global)	BMI z-scores	BMI z-score predicted decreases in self-worth for white youth only. Body dissatisfaction and peer victimization were moderating factors in the relationship. No sex differences.
Treatment Studies				
Aldaqal et al., 2013 Saudi Arabia	N= 64 50% OB 34.4% M Baseline Age: 13-17 Follow-up: 1 yr. Nationality: 72% Saudi, 28% non-Saudi	Rosenberg SES	BMI z-scores	Lower SE and Higher BMI at baseline seen in the severely obese group. After 2-year follow-up, treatment group had significantly higher SE and lower BMI than at pre-operation.
de Villiers et al, 2016 South Africa	N= 998 28% OW/OB 47.3% M Baseline Grade: 4 Follow-up: 1/2 yrs. Ethnicity: N/R	Internal (Nutrition)	BMI cut-offs	Compared to control group, those undergoing intervention had significantly greater change in nutritional SE at 2-year follow-up. No change in BMI category was seen.

SE= self-esteem; BE= body-esteem; F= females; M= males; NW= normal weight; OW=overweight; OB=obese; N/R= not reported; BMI= body mass index; PA=physical activity

2.5 Conclusions

Through the examination of past reviews and the up-to-date literature on the association between obesity and self-esteem in children and adolescents, it is clear that a significant modest relationship exists between these factors. Of the studies considered above, almost all of them indicated lower global self-worth scores among overweight and obese youth compared to those of a normal weight, with certain sub-scales being particularly affected. Considerate of many study designs, it was consistently observed that a significant inverse relationship is present between increased body mass index and lower self-esteem. There was often a higher risk or odds of having low self-esteem for one or more domains for those with overweight or obesity. Most often, global self-worth was impaired among the obese subjects, but several studies indicated that the specific dimensions of physical appearance, athletic competence, and social acceptance self-esteem were significantly impacted as well (Braet et al., 2003; Danielsen et al., 2012; Franklin et al., 2006; French et al., 1996; O'Dea, 2006; Walker et al., 2003). Some evidence has been presented for romantic, close friendship, and job self-esteem being impaired by elevated body mass in adolescents, however changes in scholastic (cognitive) competence and behavioral conduct self-esteem have not been commonly demonstrated (Griffiths et al., 2010).

Earlier studies showed inconsistency between these effects in children versus adolescents, citing that negative changes in self-esteem primarily occur among older children (French et al., 1995). A review of the newer literature has somewhat dispelled this notion, as the impacts of higher weight were observed across several age groups uniformly, however many studies point to adolescents being particularly more vulnerable

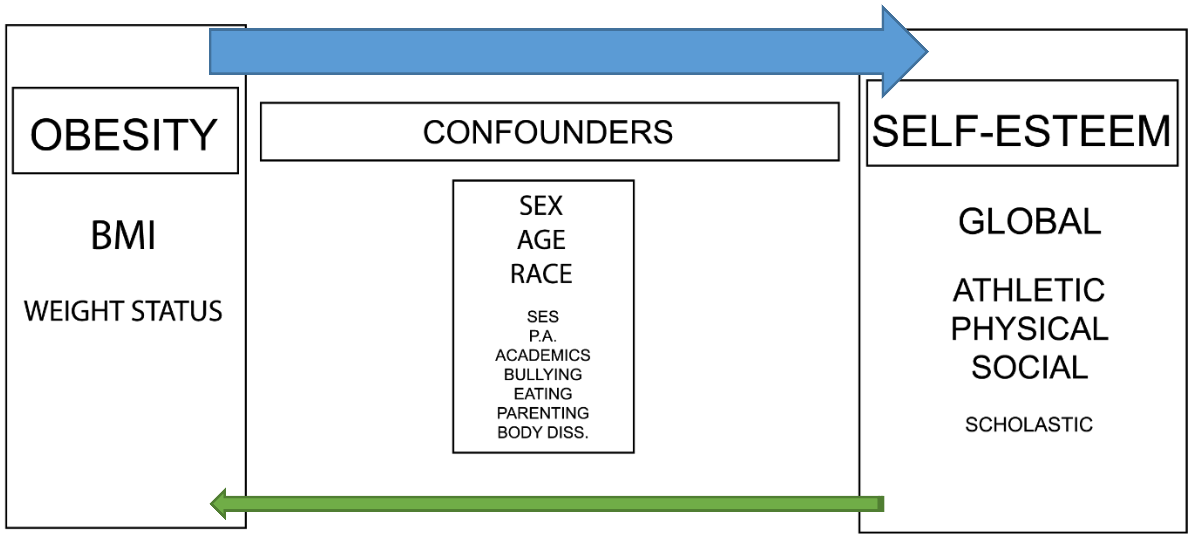
(Fedewa et al., 2016; Nowicka et al., 2009). As well, although results have been conflicting, there is a large amount of evidence pointing to females as being more likely to suffer low self-esteem overall and as a result of high body mass. Significant effects were regularly seen among both sexes, however the impacts have been repeatedly more pronounced amongst females (Abdollahi et al., 2016; Danielsen et al., 2012; Fedewa et al., 2016; Nowicka et al., 2009; Wang et al., 2009; Witherspoon et al., 2013). Race has played an important role as well, since in the studies which accounted for multiple races, there is evidence to suggest self-esteem is less impaired among African Americans compared to their non-Black peers (Fedewa et al., 2016; Strauss, 2000; Sutter et al., 2015; Witherspoon et al., 2013). In a recent systematic review, it was found that of the four studies (out of 21) which did not report significantly lower global self-esteem scores among obese groups, they were all conducted among non-white samples including minority groups in the USA and Asian populations (Hill, 2017; Sikorski, Luppa, Luck, & Riedel-Heller, 2015). These race-related differences may potentially be due to greater tolerance of higher weight among specific groups where larger bodies may be more accepted or preferred. Although a large number of studies found differences for both overweight and obese groups or combined overweight/ obese groups compared to normal weight groups, some of the studies that examined these groups separately only observed significant changes among obese or morbidly obese samples, suggesting a potential dose-response relationship where they are especially susceptible to low self-esteem (Aldaqal & Sehlo, 2013; Wang & Veugelers, 2008; Wang et al., 2009; Witherspoon et al., 2013). Similarly, those participants found in clinical samples often had lower self-esteem than obese or normal weight controls selected from community samples, possibly suggesting those seeking treatment are more adversely affected by their obesity (Wardle & Cooke, 2005)

A recent focus of this area has been on interventional studies, and although it has been consistently demonstrated that weight-loss programs lead to significantly higher self-esteem in global, physical, athletic, and social domains (Danielsen, Nordhus, Júlíusson, Mæhle, & Pallesen, 2013; Lowry et al., 2007), there has been a failure of evidence to point to actual weight loss as the sole influence of these changes (Cataldo, John, Chandran, Pati, & Shroyer, 2013; Griffiths et al., 2010; Lowry et al., 2007). Although a few studies have directly pointed to weight and BMI reductions as predictors of self-esteem improvement (Sutter et al., 2015; L. Walker, P. Gately, B. Bewick, & A. Hill, 2003), it is not necessarily a function of weight loss alone. Multifaceted treatment programs may introduce a variety of factors leading to increased self-esteem such as increased peer acceptance, and it is theorized that participation in parental and peer-supported programs may introduce other elements related to ongoing attention and treatment impacting this change.

The number of research studies examining this relationship in a longitudinal manner remains low to date, but among them changes in body mass index were consistent predictors of global and physical appearance self-esteem (O'Dea, 2006; Strauss, 2000; Sutter et al., 2015). A few key studies with relatively long follow-up periods indicate that higher BMI at baseline is associated with lower self-esteem at follow-up (Brown et al., 1998; French et al., 1996; Hesketh, Wake, & Waters, 2004; Wang et al., 2009). However, the pathway of this relationship has not been proven to be unidirectional, as some literature has demonstrated low baseline self-esteem can predict high body mass at follow-up as well as high self-esteem predicting lower body mass, thus suggesting a potential bi-lateral relationship (French et al., 1996; Jansen, Mensah, Clifford, Nicholson, & Wake, 2013; O'Brien et al., 1990).

Many mediating factors have been observed relative to this association besides the covariate effects of sex, age, and race mentioned above. Interpersonal relations, bullying and teasing, and peer victimization have been associated with lower self-esteem in all domains including global self-worth (Austin & Joseph, 1996; Danielsen et al., 2012; Eisenberg, Neumark-Sztainer, & Story, 2003; Jansen et al., 2014; Sutter et al., 2015). Besides actual weight loss in weight-management programs, physical activity, consistent parental involvement, and group-based interventions in a supportive environment allowing potential new friendships and less victimization are likely mediators of the relationship as well (Danielsen et al., 2013; McGregor, McKenna, Gately, & Hill, 2016). Other described covariates include socioeconomic status measured by household income and parental education (Wang & Veugelers, 2008), physical and sedentary activity levels (Olaya-Contreras, Bastidas, & Arvidsson, 2015; Wang & Veugelers, 2008), school performance (Wang & Veugelers, 2008; Zhang et al., 2016), disturbed eating (Danielsen et al., 2012), child-perceived parental responsiveness (Taylor et al., 2012; Zhang et al., 2016), and body dissatisfaction (Sutter et al., 2015; Taylor et al., 2012; Zhang et al., 2016). Figure 2.1 below presents the possible pathways of the relationship including relevant covariates that were explored in this research study.

Figure 2.1. The Suggested Pathway of the Obesity-Self-esteem Relationship in Youth



2.5.1 Literature gaps. Based on the conclusions made above, there is an indication of several areas lacking a thorough knowledge base. Namely, there is an evident lack of longitudinal research examining the effects of obesity on self-esteem in youth. Among only the handful of studies conducted, their follow-up periods have been relatively short, their samples consisted of narrow age groups and specific races, and oftentimes their reference groups were not measured at follow-up. Similarly, prospective studies have mostly examined the unidirectional pathway of obesity as the cause of low self-esteem, as very few studies considered a multidirectional relationship. Although the inclusion of age, sex, and race as covariates have been studied more frequently as of late, there are still not enough firm results to suggest a definite impact. As well, covariates related to obesity and self-esteem (particularly in treatment studies) such as victimization, physical activity, and socioeconomic status have only been considered in a small portion of analyses. Investigators in this area have seemingly moved towards the inclusion of validated multidimensional assessments of self-esteem, however there is still much recent literature which only evaluates global self-worth, limited individual sub-domains, or uses internally-created scales. Along the same lines, of those which attempt to categorize self-esteem, there is a large inconsistency in methodology, as no clinical threshold for real-life or functional differences in self-esteem have been established and thus categorizations have been inconsistent. Similarly, no studies have examined the factors specifically related to having high self-esteem, as there has not been a threshold described for this measure as well. Typically as a result of sample size issues, very few protocols have included participants in an underweight group, and the majority of studies combine overweight and obese subjects into one group, with also little consideration of morbidly obese youth. Thus, individual weight-group related effects have not been studied comprehensively. Aside to investigators categorizing participants based on BMI cut-offs, most studies look at objective weight or BMI, or create BMI z-scores based on international reference populations as predictors of low self-esteem. What no study has done in the past is create a BMI z-score in relation to those of the same cohort, and examine how differences among subjects impacts self-esteem longitudinally.

2.5.2 Directions for future research. Overall, the following four recommendations are suggested to guide further research in the area of self-esteem and obesity in youth:

1. Studies should include population-based cohorts with relatively large sample sizes and an age-range of children and adolescents to strengthen the internal and external validity of their results. There is a need for more prospective analyses examining the bi-directional pathway between obesity and self-esteem, with long-term follow-up periods, also accounting for baseline self-esteem and body mass.

2. Additional focus needs to be drawn to race and sex-based differences, which would entail drawing large sex-balanced samples with racial diversity including minority groups. Studies should also account for relevant covariates including peer victimization and bullying, physical and sedentary activity, body dissatisfaction, parental involvement, school performance, and socioeconomic status such as household income, parental education, and/or geography.
3. Validated multidimensional self-esteem measures should be utilized in addition to global self-worth to determine which types of competencies are most impaired by obesity. Aside to just measuring mean scores of self-esteem, categorizations of low and high self-esteem should be based on consistent cut-offs. Likewise, consistent measurement and classification scales should be used for defining obesity levels. Inclusion of underweight, normal weight, obese, and morbidly obese groups should be considered to systematically examine their characteristics.
4. Cohort-based z-scores for BMI should also be considered in a longitudinal model to examine if body mass significantly different from one's own peer-group as opposed to the general population leads to significant changes in self-esteem over time.

Chapter 3 Methods

3.1 Study Population: The P.H.A.S.T. Study and its Participants

3.1.1 Overview of PHAST. The Physical Health Activity Study Team (PHAST) study was a six-year longitudinal cohort study conducted from 2004 to 2010 among children from schools in the District School Board of Niagara (DSBN) in Ontario, Canada. It was administered by a multidisciplinary team consisting of investigators from Brock University, McMaster University, and the DSBN. Ethics approval was obtained from the respective review boards, research assistants were trained, and testing protocols were established, which can be found elsewhere (J. Cairney, Hay, Veldhuizen, Missiuna, & Faught, 2010).

3.1.2 PHAST participants. Among 90 English-speaking schools, 75 of them (83.3%) participated the study, and informed consent was obtained from 2,278 (95.8%) parents at baseline. Children aged eight to ten were followed-up from grades four through nine, being measured twice (fall and spring) in the first three years, then once in each of the subsequent three years. Informed consent was obtained at each measurement stage, and thus participants could enter or leave the study at any time-point. Make-up assessment dates were held each year for those students not present on their school's initial testing day. Each measurement period was referred to as a wave, and the time-points and sex distribution of each wave are shown in Table 3.1.

Table 3.1. The Characteristics of each PHAST Study Wave

Wave	*n*	Year of Study	Student Grade	Males (%)
1*	**2278**	1 (Fall 2004)	4	50.83
2	**2278**	1 (Spring 2005)	4	50.83
3	**2228**	2 (Fall 2005)	5	50.72
4	**2273**	2 (Spring 2006)	5	50.99
5	**2134**	3 (Fall 2006)	6	50.42
6	**2141**	3 (Spring 2007)	6	50.40
7	**1896**	4 (Fall 2007)	7	50.74
8	**1805**	5 (Fall 2008)	8	50.58
9	**1581**	6 (Fall 2009/ Winter 2010)	9	51.68

*Wave 1 was baseline pilot testing not included in the final data composition

3.1.3 PHAST measurements. At each wave, PHAST measured several factors including: physical measures (height, weight, hip, and waist circumference) by anthropometric testing; fitness and physical activity, aerobic and cardiovascular function, and motor/movement competence by a combination of measurements and questionnaires; and socio-psychological measures such as self-esteem and academic performance using self-reported, parental, and teacher surveys. Along with describing how these various measures change among children in a longitudinal manner, one of the original objectives of PHAST was to determine the factors associated with the physical activity of children. More specifically, their confidence and enjoyment in being active, their movement ability, and their physical fitness. One research goal was to determine the factors associated with motor incompetency including possible-Developmental Coordination Disorder (p-DCD).

It is important to note that Wave 1 was a pilot test of data collection, and formal data measurement began in Wave 2, thus Wave 1 was excluded from the final data set and the true first time-point is considered Wave 2. From waves 2-9, the sample sizes consecutively decreased from n=2,278 in wave 2 to n=1,581 in wave 9. At every given wave there were slightly more males, with proportions ranging from 50.40% to 50.99%, as seen in Table 3.1 above.

3.2 Data Measurement

3.2.1 Initial data organization. After obtaining approval for the use of secondary data by the Research Ethics Board of Brock University as seen in Appendix A, a research request proposal was completed and sent to the PHAST principal investigators. Upon approval, the PHAST dataset was obtained electronically from the database manager. SAS 9.4 (SAS Institute Inc., Cary, NC, USA) was used to organize and manage the data set. Among the hundreds of variables (survey questions and measurements) within the set, only measures related to the proposed research question, potential covariates, demographic measures, and participant identifiers were retained.

3.2.2 Data re-organization. The original PHAST data set was originally created in long form, where each participant represents up to eight observations, and each child has a row of data for each wave they completed (16,336 total observations). To simplify the data description process, an alternative copy of the data set was constructed in which each participant only represents one observation/row of data, thus transforming it into wide form. This was done using data transposition methods, and thus an alternative copy of the PHAST data was created herein referred to as the *transposed data set.* The transposed data set consists of 2,891 observations and 194 variables. Although the maximum number of subjects measured during one wave was 2,278 in Wave 2, the transposed data set allows the observation of 2,891 total unique participants over the six years of the study, as new students could enter at any time-point.

3.2.3 Initial data cleaning. Using preliminary data description methods, all the remaining variables were be examined for missing or unknown value descriptors. It was found that the “weight”, “waist girth”, “hip girth”, and “sitting height” variables had “999” values present, typically created when data entry assistants add a specified identifier to show a value was missing, unknown, refused, or corrupted. Therefore, to avoid these outliers causing skewed results, cleaning procedures were undertaken on both data set variants to change “999” to true missing values in the form of a period. As well, it was found that sex was incorrectly entered as “m” instead of “M” on three occasions, thus these values were corrected. Aside to removing all non-study variables from the data set, all data observations from the ninth wave were removed since high school participants were not used in the analysis.

3.2.4 Self-esteem measurements.

3.2.4.1 Harter Scale measures. Self-esteem was assessed in PHAST from grades four to eight using the Self-Perception Profile for Children (SPPC). This questionnaire was developed by Susan Harter (Harter, 2012a, 2012b) and is referred to as the Harter Scale for Children. Several validity studies have been undertaken using the Harter Scale as a measure of self-esteem in children and adolescents in several different populations (Harter, 2012b). The Harter Scale for Children is a 36-question self-reported questionnaire, which assesses self-esteem in six separate domains: Scholastic Competence, Social Competence, Athletic Competence, Physical Appearance, Behavioral Conduct, and Global Self-Worth. Each domain has six individual questions associated with it scored on a scale of 1-4, thus for each domain a child can have an overall score ranging from 6-24. The lower the overall score is for a domain, the lower the participant’s perceived competence or adequacy in that area. A copy of the Harter Scale questionnaires used in the PHAST data collection is found in Appendix B.

3.2.5 Weight-related measurements. At each wave following the receipt of informed consent, anthropometric body measures were obtained by trained research assistants. Weight was measured using a precise digital weight scale (Tanita, Tokyo, Japan) with children wearing their normal physical activity clothing without shoes, and was rounded to the nearest 0.1kg. Standing height was measured using a stadiometer (SECA, Hamburg, Germany) with shoes off and was rounded to the nearest 0.1cm. Standing height is a measure of full vertical length and was assessed by having participants stand erect with feet flat looking straight ahead in the *Frankfort Plane*, as a headpiece is lowered to make firm contact with the participant's head. Once the participant's head, shoulder blades, buttocks, and heels were in contact with the backboard, the measurement was taken while the participant held their breath. Body mass index (BMI, kg/m^2) was calculated by dividing the measured weight by the standing height (converted to metres-squared) and was not rounded. Waist girth and hip girth measure body wideness and were assessed using a non-elastic measuring tape on a standing participant and rounded to the nearest 0.1cm. For waist girth, the circumference was measured around the mid-point between the lowermost palpable rib and the uppermost border of the iliac crest. Hip girth was measured as the circumference around the widest portion of the buttocks. The waist-to-hip ratio (WHR) was calculated by dividing the measured waist girth by the hip girth, and was not rounded.

3.2.6 Covariate measurements. The wave variable indicates the time-point of the collected data, and after initial cleaning was coded from 2-8. Wave 2 refers to the first study measurement in Year 1 (grade 4: 2004/05); Wave 3 and 4 refer to Year 2 (grade 5: 2005/06); Wave 5 and 6 refer to Year 3 (grade 6: 2006/07); Wave 7 refers to Year 4 (grade 7: 2007); and Wave 8 refers to Year 5 (grade 8: 2008). Participants may have data from every wave if they did not drop out of the study, or less than eight waves if they dropped out, entered late, or missed a testing year. Participants’ age in years was calculated based on the number of days alive and rounded, at each wave. Sex of participants was self-reported by questionnaire at each wave as either male or female.

Median household income in Canadian Dollars was obtained from publically available census data corresponding to the parent/guardian reported postal code at each wave.

The geographical location of participants was accounted for in two ways. Each participating school was assigned a unique school code identifier in PHAST as a measure of relative location. As well, participants (through the parental questionnaire) indicated their postal codes, which were also transformed into unique area IDs (UAID) as a measure of relative geography within the Niagara Region. Also, since race was not asked in the surveys, the postal code data can be used to extrapolate the relative racial distribution of the study region. Theoretically, these two variables measure the same elements since they are both based on relative location within the region, and thus to avoid multicollinearity between these variables in the analysis only the unique area ID (based on postal code) will be utilized.

There were several physical activity related questions answered in the PHAST questionnaires such as time spent doing organized recreation and sedentary activity, however a relative measure of their overall physical activity level was calculated as self-reported Total Physical Activity Score from all activities, ranked on a relative scale in "total physical activity units" from 0-44. The questionnaire asks students the frequency (but not duration) of any recreational or organized physical activities completed within a one year time period, with higher scores indicating greater physical activity, at each wave. Potential activities include free-time play, intramural activities, and organized school and community sports. This scale developed by Hay (1992) for children ages 9-16 assessed reliability as high after a two-week test-retest design, and measured a moderate validity using several methods including correlations with teacher evaluations (Hay, 1992).

3.2.7 Variable transformations. Z-scores were calculated for BMI, weight, and waist circumference to assess the relative difference between a participant and the mean level of their sex at each wave. By converting these weight-related measures into z-scores, a secondary research aim of whether having significantly different body mass than one's peers leads to lower self-esteem can be addressed. The aim is to isolate how different the students are in body size from the rest of their cohort, and examine how this factor individually contributes to self-esteem changes. Using the *Standardize* Procedure in SAS, the transformations were done by wave for both males and females, and although BMI is the main indicator, weight and waist circumference z-scores were also created and assessed in the analysis to observe any potential differences. Appendix C shows each wave's mean and standard deviation for BMI by sex.

By applying the WHO international cut-offs for children based on age and sex, a baseline weight status variable was created. The grouping took place to categorize participants at baseline into normal weight, overweight, and obese categories. The resultant sample sizes of underweight and morbidly obese subjects were relatively small and thus were not categorized.

Baseline self-esteem levels as categorized by normal and low self-esteem were created for each of the Harter Scale sub-domains. Harter has suggested that for each domain question, a score below 2 is considered to be low. Thus, with the six questions in each domain, a total score below 12 is considered to be low, and a new variable was created applying this cut-off to participants at baseline.

3.2.8 Inclusion/ exclusion criteria. Aside to the initial data cleaning mentioned above, specific inclusion and exclusion criteria were applied to the data to ensure that appropriate participants remained in this study. Firstly, all participants must have at least one full wave of data including the key weight-related and self-esteem variables to be included in cross-sectional analysis. If they only had one wave of data but were missing the key variables, they were removed. Further, if subjects had only two waves of data, these must be complete and not missing any key study variables. Therefore, to be included in longitudinal analyses, all participants must have at least two waves of data containing all key variables. If they had two waves but one was incomplete, that specific wave was removed but the participant remained in the study for cross-sectional analysis. For participants with several waves of data, but missing all key weight and Harter variables at each wave, they were removed from the sample. Subsequently, any participants with age missing at every wave were also removed from the sample. Overall, 579 specific data points were removed from the analysis based on this exclusion criteria, corresponding to 24 subjects excluded.

3.2.9 Multiple imputation analysis. After the inclusion and exclusion criteria mentioned above were applied to the sample to remove unreliable observations, the remaining missing observations were examined and multiple imputation was implemented to produce unbiased estimates of the missing data. Based on the initial imputation analysis, roughly 3.5% of observations were missing and 70.5% of the observations had no missing data patterns. The Fully Conditional Specification (FCS) method for multiple imputation was used to impute the missing data since it was assumed that those specific variables' observations were missing at random. The FCS method allows variables with different distributions to be included since it uses discriminant, linear, and logistic regression imputation for categorical, continuous, and ordinal variables, respectively. Minimums and maximums were set based on the survey limits of the physical activity questionnaire, Harter Scale domains, and median household income variables. Hip girth and waist-to-hip ratio were removed from the dataset at this point since the FCS analysis revealed that these variables along with waist girth were linear combinations of each other. Five imputations of the data set were created using an arbitrary pattern, and these iterations were pooled together to create the final cleaned, imputed data set. The imputation trace plots were observed for potential patterns, and similar mean values were yielded when comparing the imputed data to the original data set, thus there was no indication of any issues with the imputation process.

3.3 Research Questions

The following research questions were addressed in this study:

1. Among a large cohort of Canadian children and adolescents from the Niagara Region, was there a correlation between body size measurements (weight, body mass index, waist circumference) and any Harter domains of self-esteem?
2. Did changes in BMI predict changes in self-esteem throughout the study? How did baseline normal weight, overweight, or obese status contribute to self-esteem levels at follow-up? Were there specific domains of self-esteem that were particularly affected by body mass changes?
3. Is there a bi-directional relationship present between body mass and self-esteem? Were there covariates present in these pathways? Did sex, age, physical activity, geography, or socioeconomic status act as significant covariates in the suggested relationships?
4. Aside to crude BMI, did the relative difference in BMI compared to the rest of the cohort (as measured by z-scores) predict changes in the self-esteem of participants?

3.4 Statistical Analysis

3.4.1 Analytic strategy. All statistical analyses were carried out using SAS 9.4 software (SAS Institute Inc., Cary, NC, USA). Statistical significance for all hypothesis tests were defined as alpha (type I error) levels equal to or below 5%, in two tails. The study utilized cross-sectional methods to observe any apparent relationships at singular points in time. However, since the literature draws an information gap in comprehensive longitudinal analyses, this was the primary focus of the study.

The initial analysis consisted of descriptive statistical measures to define the study population and visualize potential trends in the data at each time-point. To assess the potential association, correlation analyses between the key study variables were conducted, and it was hypothesized that there is a significant linear correlation present between body size measures (weight, BMI, waist circumference) and one or more self-esteem domains throughout the study. Specifically, global self-worth, physical appearance, and athletic self-esteem are the domains that the literature suggests are particularly associated with obesity.

The primary statistical model is a linear mixed models (LMM) effects analysis. This type of strategy accounts for repeated fixed and varying measures taken over time longitudinally. This analysis quantified the relationship between body mass and self-esteem throughout time while accounting for potential covariates. It was hypothesized that throughout the study period, changes in BMI significantly predict changes in specific self-esteem domains, and other factors such as sex may influence the relationship. To understand if the pathway is bi-directional, the direction of the model was flipped whereby self-esteem changes are used to predict body mass index through five years.

In order to address how having different body size specifically from one's peers impacts self-esteem, the initial models are modified using sample-based BMI z-scores instead of BMI. It was hypothesized that BMI z-score changes also significantly predict longitudinal changes in one or more domains of self-esteem.

3.4.2 Descriptive statistics. Prior to the preliminary and primary analyses, it is important to describe the characteristics of the population without the impact of covariates to observe the raw patterns of weight-related and self-esteem related variables through time, while still distinguishing by sex. To describe its properties, statistical measures were utilized including describing means and frequencies of key variables. At baseline and for each study wave, the characteristics of the sample was considered including the sample sizes and sex distributions. As well, the mean and standard deviations were calculated for all weight-related measurements, self-esteem related measurements, and covariate measurements by sex at each wave. The primary variables include BMI (kg/m^2), weight (kg), and waist circumference (cm), as well as the Harter Scale aggregate mean scores for each SPPC sub-domain by wave and sex. Other described covariates include exact age (yrs.), sex (male vs. female), median household income (CAD), and total physical activity score. For categorical variables, percentages were reported.

3.4.3 Preliminary analysis: correlation analyses.

To examine the strength of the potential relationship between the key variables, correlation analyses were conducted between all weight-related variables (BMI, weight, waist circumference) and all self-esteem variables for all waves combined. To detect all possible relationships, the same correlations were also tested using the weight-related z-scores and the Harter domain scores. Subsequently, baseline obesity status was tested against all Harter domains. Similarly, baseline self-esteem status for each domain was tested against BMI, weight, and waist circumference z-scores. These latter correlations can provide some indication of directionality among the relationship. The strength of the potential linear associations were tested using the Pearson correlation test, under the assumption of parametric data. To examine a potential monotonic relationship where the variables do not necessarily change at a constant rate or in the case of non-parametric data or categorical variables as in the latter tests, the Spearman Ranked correlation test was also performed to examine any difference in results. The correlation coefficients (ρ & ρ_s) and p-values of each tested relationship were compared, and the Pearson test values were reported. Based on the coefficients and statistical significance, a basis of further analysis was established.

3.4.4 Primary analysis: linear mixed-effects modelling. Since the data set contains measurements recorded at multiple time-points in a five-year span, mixed-effects modelling allows repeated measures to be accounted for within the analysis, and thus it was the primary analytic model of the study. Additionally, the linear mixed model (LMM) allows the incorporation of fixed effects, as well as effects that vary for each individual, which is a unique feature of the analysis. The random effects accounted for include the model intercept, and unique school area ID code (UAID). The fixed effects of the independent variables were tested by the creation of slopes estimating their impact, and their t-value and *p*-values were interpreted to examine significance. Unstructured covariance matrices were created to estimate the differences in dependent variable values between all waves since the distance between time-points were not equally spaced. The differences of least square means at every wave were calculated using the Tukey-Kramer adjustment method and the t-value and *p*-value were interpreted to determine if significant differences existed after controlling for covariates. There were three distinct sets of linear mixed models created in the analysis. Firstly, models examining the association of self-esteem with weight-related changes through five years were created. Secondly, the primary models were modified to include BMI z-score instead of crude

BMI score to predict the changes in self-esteem scores as a result of z-score differences. And finally, the direction of the original models was flipped whereby body mass index throughout the study was predicted as a result of self-esteem changes. Table 3.2 outlines the linear mixed-effects models created to address the study questions.

In general, the longitudinal relationship between body mass index and self-esteem was examined. Based on preliminary results, it was determined that independent variable would be crude BMI scores due to their significance in prior correlation analysis. Six unique variations of this model were created, one with each of the self-esteem domain scores as the dependent variable. Using mixed-effect modelling, the predicted change in individuals' self-esteem domain scores were estimated over a five-year time period of waves 2-8, adjusting for repeatedly measured BMI. The models were fit accounting for other independent covariates including study wave, baseline obesity status, sex, age, geography, socioeconomic status as median household income, and physical activity, along with the interactions between these variables. Non-significant interactions were omitted from the final iterations, and thus only interactions between physical activity-obesity status, and physical activity-sex remained. The main goal was to understand how self-esteem changes in relation to BMI longitudinally, and the first set of mixed-effects models were able to describe this.

The second set of models were a modified version of the first set, whereby BMI z-scores were used as the independent variables, predicting changes in three self-esteem domains over the five-year study period. Covariates included as independent variables in the model include study wave, sex, age, geography, SES, and physical activity scores, along with any significant interactions.

The last set of models examine a potentially reversed pathway, whereby changes in self-esteem over the study predict body mass index changes. There were also three iterations of this model created, one for each Harter domain score as the independent variable, with BMI consistently used as the dependent variable. Covariates included as independent variables in the model include study wave, baseline self-esteem status, sex, age, geography, SES, and physical activity scores, along with any significant interactions.

Table 3.2. The Constructed Linear Mixed-Effects Models

Dependent Variable	**Independent Variables- Fixed Effects Repeated Measures**	**Random Effects**
Model 1		
Self-Esteem Harter Score	Wave, BMI, Baseline Obesity, Sex, Age, Geography, SES, Physical Activity, Interactions	Intercept, School ID
1a. Global Self-Worth		
1b. Physical Appearance		
1c. Athletic		
1d. Social		
1e. Behavioral		
1f. Cognitive		
Model 2		
Self-Esteem Harter Score	Wave, BMI Z-Score, Sex, Age, Geography, SES, Physical Activity, Interactions	Intercept, School ID
2a. Global Self-Worth		
2b. Physical Appearance		
2c. Athletic		
Model 3		
Body Mass Index	*3a.* Wave, Global SW Score, Baseline Global SW, Sex, Age, Geography, SES, Physical Activity, Interactions *3b.* Wave, Physical SE Score, Baseline Physical SE, Sex, Age, Geography, SES, Physical Activity, Interactions *3c.* Wave, Athletic SE Score, Baseline Athletic SE, Sex, Age, Geography, SES, Physical Activity, Interactions	Intercept, School ID

Chapter 4 Results

4.1 Descriptive Statistics

Table 4.1 below shows the characteristics of 2,241 study participants included at baseline, separated by sex with indications of any statistical differences between males and females for key study variables. The cleaned, non-imputed data set was used in the creation of these statistics. The proportion of males and females was relatively equal, with 50.6% males at the first study wave. The physical characteristics of weight, BMI, and waist circumference were all relatively equal as well, with no statistical significance between sexes. Also, there were no differences in the proportions of normal weight, overweight, and obese subjects. No differences were observed in baseline median household income nor the total physical activity scores. The self-esteem variables showed some differences between males and females at baseline. For both raw domain scores and categorized self-esteem, no differences were found between low/ normal global self-worth, social, and cognitive self-esteem. However, physical appearance, athletic, and behavioral self-esteem at baseline were significantly different for males and females, with significance levels as low as <0.0001.

Table 4.1. Baseline characteristics of 2,241 children, by sex

	Males	**Females**	**Significance**
n (%)	***1135 (50.6)***	***1106 (49.4)***	NS
Age [SD], yrs.	9.9 [0.37]	9.9 [0.34]	*
Weight [SD], kg	36.3 [8.7]	36.4 [9.1]	NS
BMI [SD], kg/m^2	18.5 [3.5]	18.6 [3.6]	NS
Waist Circum. [SD], cm	65.0 [10.0]	65.0 [10.1]	NS
Harter Scale Scores			
Global SW	20.1 [3.9]	20.2 [3.9]	NS
Physical SE	19.5 [4.1]	19.0 [4.7]	**
Athletic SE	19.0 [3.9]	17.8 [4.3]	***
Social SE	18.5 [4.2]	18.5 [4.4]	NS
Behavioral SE	18.3 [4.2]	19.9 [3.9]	***
Cognitive SE	18.1 [4.1]	18.3 [4.3]	NS
Obesity Status (%)			NS
Normal Weight	70.4	66.3	
Overweight¶	19.8	22.2	
Obese§	9.8	11.5	
Self-Esteem~ (% Low)			
Global SW	3.4	3.9	NS
Physical SE	4.9	8.7	**
Athletic SE	4.3	8.9	***
Social SE	6.4	8.3	NS
Behavioral SE	7.0	3.5	**
Cognitive SE	7.0	6.3	NS
HH Income [SD], $CAD°	60928.2 [19246.3]	61454.2 [18706.1]	NS
PA Score [SD]	15.4 [7.0]	15.2 [6.4]	NS

Note: BMI= body mass index, SW= self-worth, SE= self-esteem, PA= physical activity, SD= standard deviation, NS= non-significant
*****Indicates significance at p≤0.05, ******Indicates significance at p≤0.01, *******Indicates significance at p≤0.0001
¶Overweight status defined in the top 85-95% BMI WHO cut-offs, §Obese status defined in top 5% BMI WHO cut-offs
~Low self-esteem status defined as mean domain score <12
°Baseline Median Household Income first recorded at wave 3, derived from postal code

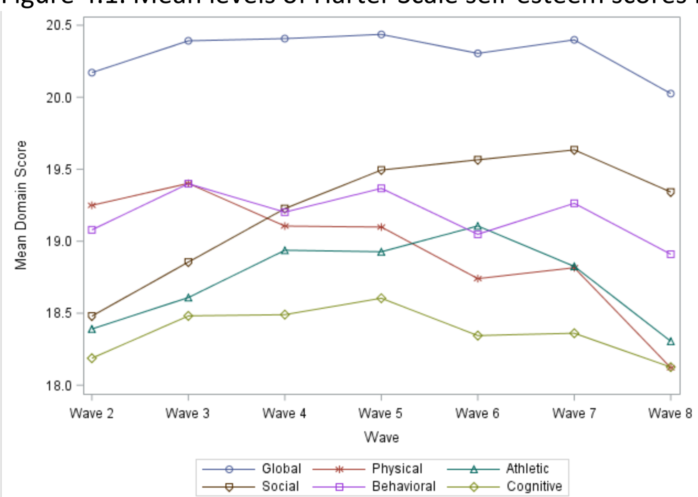
Table 4.2 below shows the mean levels of the key study variables at each wave from grades four to eight where the study sample consisted of 2,241 participants at the first time-point, down to 1,696 participants at the eighth wave. On average, the mean age at baseline was 9.9 years old, and at the final study wave 13.4 years old. From waves 2-7, the mean age increased by approximately half a year, and at wave 8 the mean age increased by approximately one full year. The mean weight, body mass index, and waist circumference of participants increased at every measurement period. Weight increased from 36.3kg at baseline by approximately two units at each half-year measurement period, with the largest increase of approximately 6 kg during the full-year between grades seven and eight. Similar trends were observed with BMI and waist circumference, with the largest differences between waves 7-8. The table also shows the mean self-esteem domain scores at each wave, in which not all increased with time. Figure 4.1 models the observed patterns of self-esteem with time. Global self-worth had the highest average scores at each wave with a baseline of 20.2, and remained relatively the same until wave 8 where a relatively sharp decrease occurred of 0.4 units. Cognitive self-esteem had the lowest mean scores at each wave, with a baseline of 18.2 and a final score of 18.1, where it slightly increased up to wave 5, then decreased until wave 8. Social self-esteem had a mean baseline score of 18.5, but consistently increased in every wave up to a value of 19.6 in wave 7, until a relatively sharp decrease occurred at wave 8. Athletic self-esteem followed the same pattern as cognitive and social self-esteem, where it slowly increased up to wave 6 then steeply fell to wave 8. Behavioral self-esteem increased then decreased at every other wave in a relatively uniform zig-zag pattern, starting at 19.1 and finishing slightly less at 18.9. The domain of physical appearance self-esteem showed the largest difference in magnitude from beginning to end, where it consistently decreased a total of 1.1 units from 19.2 to 18.1, with a very steep drop at wave 8.

Table 4.2. Mean levels of key study variables for children, by wave*

Wave	**2**	**3**	**4**	**5**	**6**	**7**	**8**
n	***2241***	***2126***	***2124***	***2092***	***2064***	***1883***	***1696***
Age [SD], yrs.	9.9 [0.4]	10.3 [0.4]	10.8 [0.5]	11.3 [0.3]	11.9 [0.4]	12.4 [0.3]	13.4 [0.3]
Weight [SD], kg	36.3 [8.9]	38.5 [9.6]	40.9 [10.3]	43.5 [11.2]	46.7 [11.9]	49.0 [12.1]	55.0 [13.0]
BMI [SD], kg/m^2	18.6 [3.5]	19.0 [3.7]	19.2 [3.8]	19.7 [4.0]	20.0 [4.0]	20.3 [4.1]	21.2 [4.2]
WC [SD], cm	65.0 [10.1]	67.4 [10.4]	69.1 [10.5]	70.6 [11.3]	71.7 [11.3]	71.6 [11.0]	74.3 [11.7]
Self-Esteem [SD]							
Global	20.2 [3.9]	20.4 [3.7]	20.4 [3.7]	20.4 [3.6]	20.3 [3.7]	20.4 [3.6]	20.0 [3.5]
Physical	19.2 [4.4]	19.4 [4.4]	19.1 [4.5]	19.1 [4.4]	18.7 [4.5]	18.8 [4.3]	18.1 [4.4]
Athletic	18.4 [4.1]	18.6 [4.1]	18.9 [4.0]	18.9 [4.0]	19.1 [3.9]	18.8 [3.9]	18.3 [4.1]
Social	18.5 [4.3]	18.9 [4.1]	19.2 [4.1]	19.5 [3.9]	19.6 [4.0]	19.6 [3.8]	19.3 [3.7]
Behavioral	19.1 [4.1]	19.4 [4.1]	19.2 [4.2]	19.4 [4.0]	19.0 [4.1]	19.3 [4.0]	18.9 [3.9]
Cognitive	18.2 [4.2]	18.5 [4.1]	18.5 [4.1]	18.6 [4.0]	18.3 [4.0]	18.4 [4.0]	18.1 [4.0]

Note: BMI= body mass index, WC= waist circumference, SD= standard deviation
*Wave 2= spring 2005, wave 3= fall 2005, wave 4= spring 2006, wave 5= fall 2006, wave 6= spring 2007, wave 7= fall 2007, wave 8= fall 2008

Figure 4.1. Mean levels of Harter Scale self-esteem scores for participants, by wave*

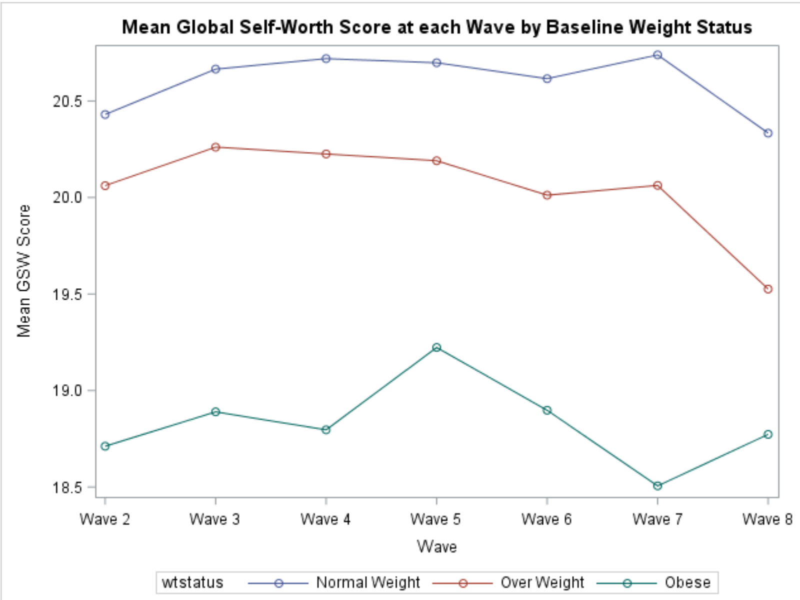


*Wave 2= spring 2005, wave 3= fall 2005, wave 4= spring 2006, wave 5= fall 2006, wave 6= spring 2007, wave 7= fall 2007, wave 8= fall 2008

Figure 4.2 below uses the cleaned, imputed data set to visualize the trends in mean self-esteem scores by domain over time, according to baseline weight status as normal weight, overweight, and obese. As can be seen in all self-esteem domains aside from behavioral, those who were obese at baseline had visibly lower mean self-esteem than the others at every time point. The global self-worth and physical appearance self-esteem domain scores for those who were overweight at baseline were visibly less than normal weight individuals at each time point as well. For example, at baseline the physical self-esteem scores were 19.98, 18.59, and 15.83 for the normal weight, overweight, and obese groups, respectively. The general trend was that these values decreased over time, with the largest drop from wave 7 to 8. At the wave 8 follow-up, the three groups had physical scores of 18.92, 16.88, and 14.72, respectively. In the athletic and social self-esteem domains, although the obese group has much lower values, there are not visible differences between the normal weight and overweight groups over time, since the plots cross several times as one group is not consistently lower than the other across waves. In general however, these domains seem to rise slowly throughout time then experience a decrease after the sixth wave, corresponding to an age of approximately twelve years. In the behavioral domain, there is crossover between all three groups at several time points as the plots are relatively close to each other. For example, the obese group has the lowest baseline score, but the highest at wave 5, and the overweight group has the highest score at wave 3, but the lowest score at waves 4 and 8. The cognitive self-esteem domain shows the overweight group having the highest score until wave 7 and 8, where the normal weight group then has the highest values.

In general, the baseline obese group had lower scores at most time points, but moved in the relatively same pattern as the other groups. However, it appears that in most cases the obese groups showed different changes from the seventh to eighth wave than the other groups. Whereas the normal weight and overweight groups in all domains were characterized by sharp decreases from wave 7 to 8, it looks as though the obese group endured less drastic reductions in self-esteem scores at that time point and even in the cases of global, physical, social, and cognitive self-esteem saw no reduction or an increase in scores.

Figure 4.2. Mean self-esteem domain scores by study wave according to baseline obesity status



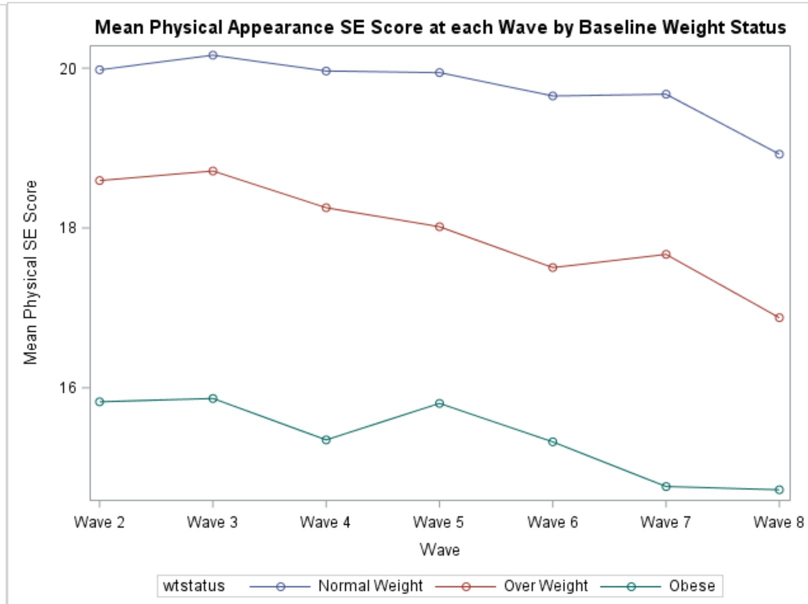


Figure 4.2, continued.

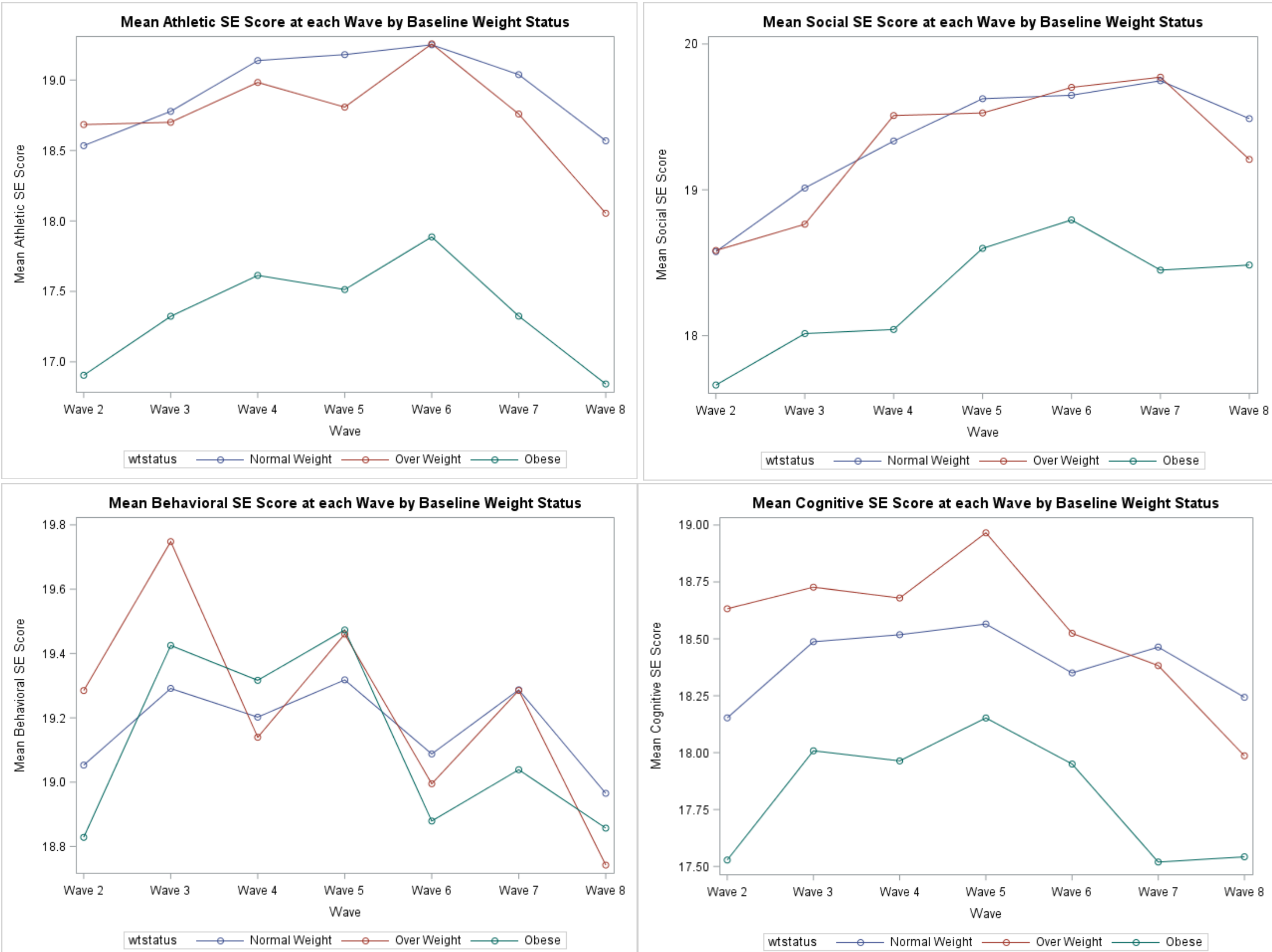
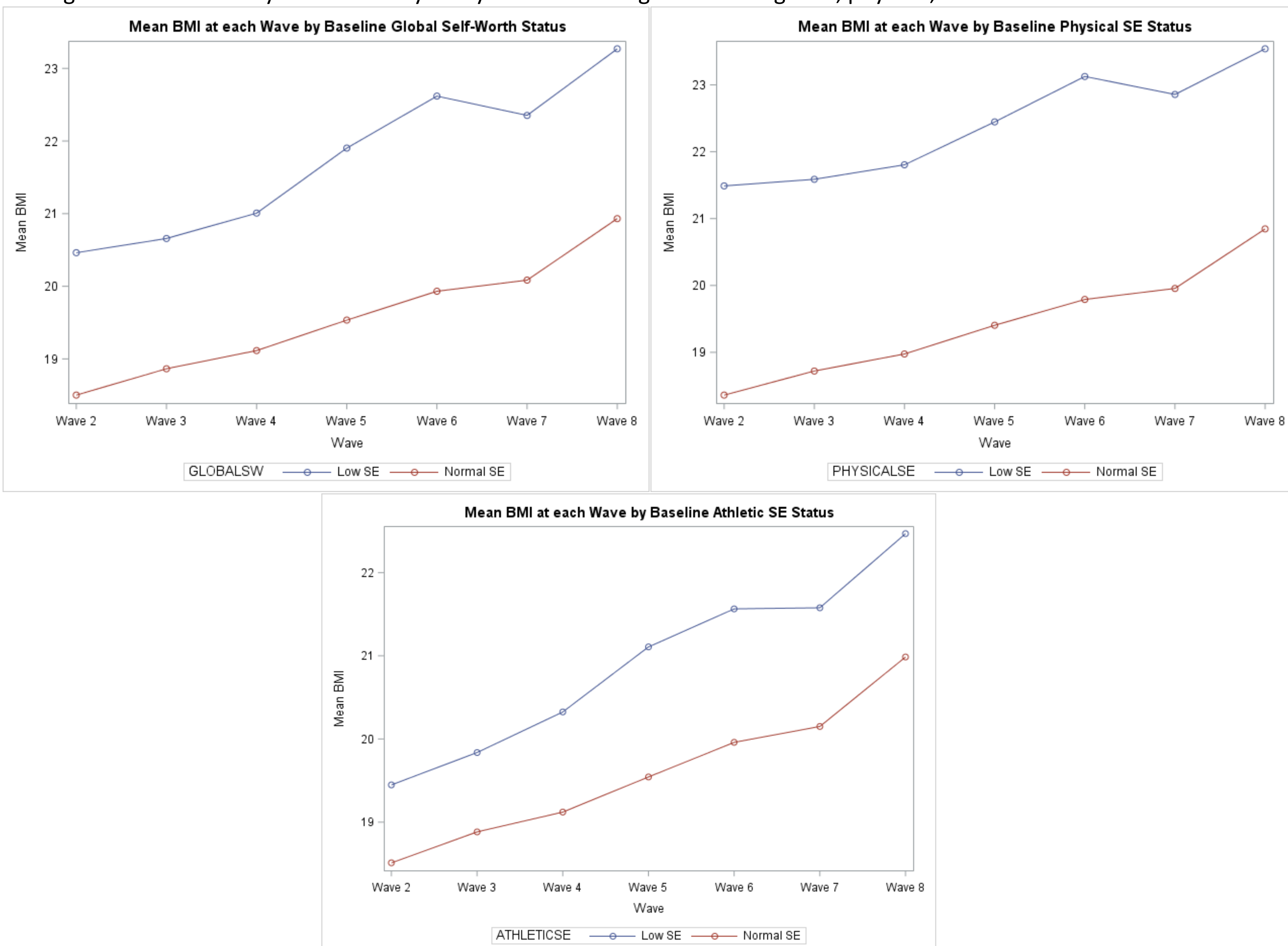


Figure 4.3 uses the cleaned, imputed data to visualize body mass index over time according to baseline self-esteem status. The domains of global self-worth, physical, and athletic self-esteem were grouped into low and normal status to examine any potential trends. For each domain, those with normal self-esteem at baseline have visibly lower BMI at each study wave. The largest gaps in BMI between the low and normal groups are among the physical appearance self-esteem domain, where at baseline the values were 18.36 and 21.49 kg/m^2, respectively, indicating a difference of over 3 units. This large gap was maintained at each wave, with a difference of 2.7 kg/m^2 at wave 8. In general both groups' BMI moved in the same patterns for each domain, with small increases up until wave 6, then a decrease at wave 7, with a steep increase at the final wave. These patterns were also examined over time with weight and waist circumference instead of BMI, and these plots can be found in Appendix D.

Figure 4.3. Mean body mass index by study wave according to baseline global, physical, and athletic self-esteem status



4.2 Preliminary Analysis: Correlation Analysis

Correlation analyses were conducted on the key study variables among the cleaned, imputed data set and the results are seen in Table 4.3. The weight-related measures consisting of BMI, weight, and waist circumference, along with their z-scores were tested against the six self-esteem domain scores. Among every significant correlation, the relationship was found to be negative whereby increases in weight-related measures are associated with decreases in self-esteem measures, and vice versa. The domain of physical self-esteem had the highest correlation magnitude, with *r* values ranging from -0.30 to -0.35, of which BMI was the largest, indicating a negative weak to moderate, significant relationship ($p<0.0001$). Global self-worth also demonstrated a significant weak negative relationship ($p<0.0001$) with a correlation coefficient of -0.17 for BMI. The athletic domain had weak yet significant correlations with weight measures. Social, cognitive, and behavioral self-esteem also had very low magnitudes, however they were significant ($p<0.05$) with body mass index and waist circumference, but not weight. The social domain was not significantly correlated with the weight score. Overall among all domains, BMI had the largest correlation coefficients, followed by waist circumference, then weight. When examining the correlations of the weight-related variables' z-scores, they were almost identical and provided the same results as the raw scores.

Baseline obesity status was tested against each self-esteem domain score, and the results were consistent indicating weak to moderate negative relationships with global and physical self-esteem ($p<0.0001$), weak negative relationships with athletic, social, and cognitive self-esteem ($p<0.01$), and a non-significant relationship with behavioral self-esteem.

The correlations between baseline self-esteem statuses and weight-related scores were also analyzed. Among these correlations, there were very small differences in the magnitudes of BMI, weight, and waist circumference. Once again, weak to moderate negative relationships existed for physical (r=-0.23) and global (r=-0.16) self-esteem, indicating lower baseline self-esteem status is associated with higher BMI ($p<0.0001$). Baseline athletic, social, behavioral, and cognitive self-esteem status all yielded weak yet significant ($p<0.0001$) correlations with weight-related scores.

Table 4.3. The Pearson correlation coefficients and significance levels

***r* Coefficient** Variable	Global	Physical	Athletic	Social	Behavioral	Cognitive
BMI	**-0.17**	**-0.35**	**-0.097**	**-0.040**	**-0.023**	**-0.030**
BMI Z-Score	**-0.17**	**-0.34**	**-0.096**	**-0.055**	**-0.022**	**-0.027**
Weight	**-0.13**	**-0.30**	**-0.060**	0.00093	-0.0086	-0.0062
Weight Z-Score	**-0.14**	**-0.29**	**-0.066**	**-0.038**	-0.0024	0.00039
WC	**-0.15**	**-0.33**	**-0.098**	**-0.042**	**-0.020**	**-0.031**
WC Z-Score	**-0.16**	**-0.32**	**-0.11**	**-0.066**	**-0.017**	**-0.031**
Baseline Obesity¶	**-0.14**	**-0.31**	**-0.10**	**-0.067**	0.00091	**-0.026**
	Baseline~ Global	**Baseline Physical**	**Baseline Athletic**	**Baseline Social**	**Baseline Behavioral**	**Baseline Cognitive**
BMI	**-0.16**	**-0.23**	**-0.11**	**-0.096**	**-0.077**	**-0.090**
Weight	**-0.16**	**-0.21**	**-0.11**	**-0.096**	**-0.076**	**-0.083**
WC	**-0.15**	**-0.22**	**-0.11**	**-0.10**	**-0.075**	**-0.086**

Note: Values in bold indicates significance at p≤0.05

r= Pearson correlation coefficient estimate, BMI= body mass index, WC= waist circumference

¶Overweight status defined in the top 85-95% BMI WHO cut-offs, Obese status defined in top 5% BMI WHO cut-offs

~Baseline Low self-esteem status defined as mean domain score <12

4.3 Primary Analysis: Linear Mixed-Effects Modelling

4.3.1 Body mass index as a predictor of self-esteem. Six linear mixed-effects models were constructed with each domain of self-esteem as the dependent variable, as seen in Tables 4.4.a and 4.4.b. The main independent variable used was body mass index score (kg/m^2), and covariates included in the models were time (study wave 2-8), baseline obesity status (normal weight, overweight, obese) defined by WHO cut-offs, sex (male versus female), age (years), physical activity score (total units), and various interactions of significant predictors. The factors listed above were considered fixed effects in the model, and the individual intercepts were added as random effects. In these and all subsequent models, school location and median household income were omitted due to their non-significance. Since the data came from a longitudinal cohort study, wave was specified as a repeated measure. The between-within method was used as the degrees of freedom method in the model, and unstructured covariance matrices were created since the distance between time points were not all equal, with the Tukey adjustment method used to estimate means.

In model 1 which considered global self-worth as the dependent variable, with all else held constant, the average global self-worth intercept estimate was 23.36 (95% CI: 21.16, 25.56, $p<0.0001$). In comparison to the baseline score referenced at wave 2, there was a slight increase in GSW with each subsequent wave, ranging from 0.39 units at wave 3 to 0.82 units at wave 8, all of which were statistically significant. On average, with each unit increase in body mass index, the global self-worth score decreased by 0.10 units (95% CI: -0.14,-0.064, $p<0.0001$). This statistic refers to the overall decrease throughout the study period, and cannot be inferred to one specific interval of time. In comparison to those considered normal weight at baseline, those who were overweight had a non-significant lower GSW by an average of 0.15 units (95% CI: -0.64, 0.34, $p=0.544$). However, those who were obese at baseline had an average score 1.24 units lower (95% CI: -2.08, -0.40, $p<0.01$). Sex and age were both non-significant predictors in the model. With every unit increase in total physical activity score, the average global self-worth score increased by 0.056 units (95% CI: 0.044, 0.068, $p<0.0001$). The interaction of physical activity score and baseline obesity status was added to the model, and it was seen that GSW scores were 0.038 units higher (95% CI: 0.0045, 0.071, $p<0.05$) on average with each increase in PA unit, in those who were obese at baseline. For those who were overweight at baseline, a non-significant increase of 0.011 was seen with physical activity units (95% CI: -0.012, 0.034, $p=0.348$).

The second model examined physical appearance self-esteem as the dependent variable, and it was found that the intercept was also 23.36 units (95% CI: 20.91, 25.82, $p<0.0001$). The only significant change in physical score with time compared to wave 2 was at wave 3, with an increase of 0.31 (95% CI: 0.10, 0.51, $p<0.01$). With every one unit increase in BMI, the average physical self-esteem score decreased by 0.25 units (95% CI: -0.29, -0.21, $p<0.0001$). Compared to those of a normal weight at baseline, physical self-esteem score decreased, on average, 0.75 units (95% CI: -1.18, -0.32, $p<0.001$) among those who were overweight, and 2.32 units (95% CI: -2.99, -1.66, $p<0.0001$) among those who were obese. Compared to females, males had a score that was 0.55 units higher (95% CI: 0.25, 0.85, $p<0.001$), on average. As in model 1, age was not a significant predictor, and increases in physical activity score predicted higher self-esteem scores ($\beta=0.059$, 95% CI: 0.048, 0.069, $p<0.0001$). The interaction between sex and baseline obesity status was added to the model, and it was seen that in comparison to normal weight females, being an obese male predicted a higher physical self-esteem by 1.16 units (95% CI: 0.35, 1.97, $p<0.01$). Males who were overweight also had increased physical self-esteem with physical activity, however this effect was non-significant ($\beta=0.54$, 95% CI: -0.091, 1.18, $p=0.0919$).

The third model examined changes in athletic ability self-esteem, and found an intercept of 16.60 units (95% CI: 14.40, 18.81, $p<0.0001$). In comparison to wave 2, the changes in self-esteem score significantly differed at waves 3 to 7. With each unit increase of BMI, the average athletic self-esteem score slightly decreased by 0.043 units (95% CI: -0.076, -0.00946, $p<0.05$). Baseline overweight was not found to be significant, however baseline obesity in comparison to normal weight resulted in a 1.51 unit decrease (95% CI: -2.15, -0.87, $p<0.0001$) in athletic ability self-esteem. Males had a 1.29 unit higher score (95% CI: 1.07, 1.51, $p<0.0001$) on average, and once again age was a non-significant predictor while physical activity score was again significant showing higher self-esteem with greater physical activity. The interaction between physical activity and baseline obesity was included, and among those who were obese, increases in PA score increased athletic self-esteem by 0.047 units (95% CI: 0.0169, 0.0765, $p<0.01$) on average.

In the fourth model which examined social self-esteem (Table 4.4.b), the average value (intercept) was 17.22 (95% CI: 14.90, 19.53, $p<0.0001$). Compared to wave 2, each subsequent wave had a significant increase in self-esteem score ranging from 0.41 to 1.16 units ($p<0.05$). Body mass index score as well as overweight status were non-significant predictors of social self-esteem. However, compared to those of a normal baseline weight, those who were overweight or obese had a lower score, but only those who were obese reached statistical significance (β=-1.66, 95% CI: -2.39, -0.92, $p<0.0001$). Similar to the global self-worth model, both sex and age in this model were non-significant predictors of social self-esteem. Total physical activity score was again a significant predictor (β=0.091, 95% CI: 0.079, 0.10, $p<0.001$), and the interaction of physical activity score and baseline weight status showed that with each increase in PA unit in those who were obese, social self-esteem score increased on average by 0.048 (95% CI: 0.015, 0.081, $p<0.01$) units.

The fifth model included behavioral self-esteem, and the intercept was 20.88 units (95% CI: 18.44, 23.31, $p<0.0001$). Compared to wave 2, only self-esteem comparisons at waves 3 and 5 showed significantly higher changes ($p<0.01$). With each kg/m^2 increase in body mass index, the average behavioral self-esteem score decreased by 0.047 units (95% CI: -0.092, -0.0025, $p<0.05$). Although both groups showed non-significance, compared to those who were normal weight at baseline, those who were overweight and obese had higher self-esteem scores of 0.19 (95% CI: -0.22, 0.60, $p=0.355$) and 0.42 (95% CI: -0.29, 1.14, $p=0.233$) units, respectively. For this domain, sex had a highly significant effect as males had an average behavioral score 1.67 units lower (9%% CI: -2.05, -1.28, $p<0.0001$). Once again, age was non-significant, but physical activity score was a significant predictor of higher behavioural self-esteem in the model (β=0.052, 95% CI: 0.038, 0.067, $p<0.0001$).

The final model examining cognitive (scholastic) ability self-esteem had an intercept of 18.15 units (95% CI: 15.68, 20.62, $p<0.0001$), and again only baseline time changes at wave 3 and 5 led to significantly higher ($p<0.01$) scores. Neither BMI nor baseline weight status were significant predictors in this model. Similar to previous models, sex and age were both non-significant factors, however with each unit increase in physical activity score, the average cognitive self-esteem score increased by 0.08 units (95% CI: 0.070, 0.090, $p<0.0001$).

Figure 4.4 illustrates the predicted means of the Harter sub-scales according to baseline obesity status. Somewhat similar to the mean domain scores reported in Figure 4.2, the visualized curves reveal that for the global, physical, athletic, and social domains those who are normal weight have the highest self-esteem, followed by overweight, then obese with the lowest scores. In the global, athletic, and social domains, the slopes of the normal weight and overweight subjects do not differ by a lot, whereas the obese group has significantly lower self-esteem. However, among the physical appearance domain, there is a large difference between all three weight groups, with the largest difference from the normal weight to obese subjects. In the behavioral domain, the overweight and obese groups have much greater self-esteem than the normal weight group. The patterns also quite differ in the cognitive domain, where the overweight group has a much higher self-esteem than the normal weight group.

Table 4.4, a. Estimated change in global, physical, and athletic self-esteem domain scores over follow-up in relation to body mass index and other predictors using linear mixed-effects regression models

	Model 1 (DV= Global SW)		Model 2 (DV= Physical SE)		Model 3 (DV= Athletic SE)	
Variable	**β (95% CI)**	**Sig.**	**β (95% CI)**	**Sig.**	**β (95% CI)**	**Sig.**
Intercept	23.36 (21.2, 25.6)	***	23.36 (20.9, 25.8)	***	16.60 (14.4, 18.8)	***
Study Wave (ref. Wave 2)						
3	0.39 (0.21, 0.57)	***	0.31 (0.10, 0.51)	**	0.32 (0.15, 0.49)	**
4	0.37 (0.12, 0.61)	**	-0.035 (-0.31, 0.24)	NS	0.32 (0.082, 0.56)	**
5	0.72 (0.37, 1.07)	***	0.25 (-0.14, 0.64)	NS	0.71 (0.36, 1.06)	***
6	0.58 (0.13, 1.04)	*	-0.13 (-0.64, 0.39)	NS	0.54 (0.085, 1.00)	*
7	0.88 (0.31, 1.45)	**	0.065 (-0.58, 0.71)	NS	0.67 (0.094, 1.24)	*
8	0.82 (0.04, 1.61)	*	-0.34 (-1.22, 0.54)	NS	0.40 (-0.38, 1.19)	NS
BMI (per kg/m^2)	-0.10 (-0.14, -0.06)	***	-0.25 (-0.29, -0.21)	***	-0.043 (-0.076, -0.0095)	*
Baseline Weight¶ (ref. Normal WT)						
Overweight	-0.15 (-0.64, 0.34)	NS	-0.75 (-1.18, -0.32)	**	0.051 (-0.44, 0.54)	NS
Obese	-1.24 (-2.08, -0.40)	**	-2.32 (-2.99, -1.66)	***	-1.51 (-2.15, -0.87)	***
Sex (male)	-0.045 (-0.26, 0.17)	NS	0.55 (0.25, 0.85)	**	1.29 (1.07, 1.51)	***
Age (per year)	-0.21 (-0.42, 0.0067)	NS	-0.04 (-0.29, 0.20)	NS	-0.048 (-0.27, 0.17)	NS
PA Score (per unit)	0.056 (0.044, 0.068)	***	0.059 (0.048, 0.069)	***	0.16 (0.14, 0.17)	***
PA x Overweight	0.011 (-0.012, 0.034)	NS	--	--	0.00050 (-0.022, 0.023)	NS
PA x Obese	0.038 (0.0045, 0.071)	*	--	--	0.047 (0.017, 0.077)	**
Male x Overweight	--	--	0.54 (-0.091, 1.18)	NS	--	--
Male x Obese	--	--	1.16 (0.35, 1.97)	**	--	--

Note: DV= dependent variable, β= coefficient estimate, Sig= Significance, BMI= body mass index, WT= weight, PA= physical activity, NS= non-significant
*****Indicates significance at p≤0.05, ******Indicates significance at p≤0.01, *******Indicates significance at p≤0.0001
¶Overweight status defined in the top 85-95% BMI WHO cut-offs, Obese status defined in top 5% BMI WHO cut-offs

Table 4.4, b. Estimated change in social, behavioral, and cognitive self-esteem domain scores over follow-up in relation to body mass index and other predictors using linear mixed-effects regression models

	Model 4 (DV= Social SE)		Model 5 (DV= Behavioral SE)		Model 6 (DV= Cognitive SE)	
Variable	β (95% CI)	Sig.	β (95% CI)	Sig.	β (95% CI)	Sig.
Intercept	17.22 (14.9, 19.5)	***	20.88 (18.4, 23.3)	***	18.15 (16.7, 20.6)	***
Study Wave (ref. Wave 2)						
3	0.41 (0.22, 0.59)	***	0.40 (0.20, 0.59)	***	0.35 (0.15, 0.54)	**
4	0.56 (0.31, 0.82)	***	0.16 (-0.10, 0.42)	NS	0.24 (-0.024, 0.51)	NS
5	1.05 (0.68, 1.42)	***	0.53 (0.14, 0.91)	**	0.59 (0.21, 0.97)	**
6	0.90 (0.41, 1.38)	**	0.12 (-0.38, 0.63)	NS	0.19 (-0.32, 0.69)	NS
7	1.16 (0.56, 1.76)	**	0.44 (-0.18, 1.07)	NS	0.34 (-0.30, 0.98)	NS
8	0.94 (0.12, 1.77)	*	0.18 (-0.68, 1.03)	NS	0.27 (-0.61, 1.14)	NS
BMI (per kg/m^2)	-0.00048 (-0.040, 0.039)	NS	-0.047 (-0.092, 0.0025)	*	-0.027 (-0.066, 0.012)	NS
Baseline Weight¶ (ref. Normal WT)						
Overweight	-0.20 (-0.79, 0.40)	NS	0.19 (-0.22, 0.60)	NS	0.29 (-0.092, 0.67)	NS
Obese	-1.66 (-2.39, -0.92)	***	0.42 (-0.29, 1.14)	NS	-0.21 (-0.83, 0.41)	NS
Sex (male)	-0.083 (-0.32, 0.15)	NS	-1.67 (-2.06, -1.28)	***	0.0070 (-0.24, 0.26)	NS
Age (per year)	-0.0029 (-0.23, 0.22)	NS	-0.10 (-0.34, 0.14)	NS	-0.075 (-0.31, 0.17)	NS
PA Score (per unit)	0.091 (0.079, 0.10)	***	0.052 (0.038, 0.067)	***	0.080 (0.070, 0.090)	***
PA x Overweight	0.0087 (-0.017, 0.035)	NS	--	--	--	--
PA x Obese	0.048 (0.015, 0.082)	**	--	--	--	--
Male x Overweight	--	--	--	--	--	--
Male x Obese	--	--	--	--	--	--

Note: DV= dependent variable, β= coefficient estimate, Sig= Significance, BMI= body mass index, WT= weight, PA= physical activity, NS= non-significant
*Indicates significance at p≤0.05, **Indicates significance at p≤0.01, ***Indicates significance at p≤0.0001
¶Overweight status defined in the top 85-95% BMI WHO cut-offs, Obese status defined in top 5% BMI WHO cut-offs

Figure 4.4. The predicted slopes of mean self-esteem scores according to baseline obesity status

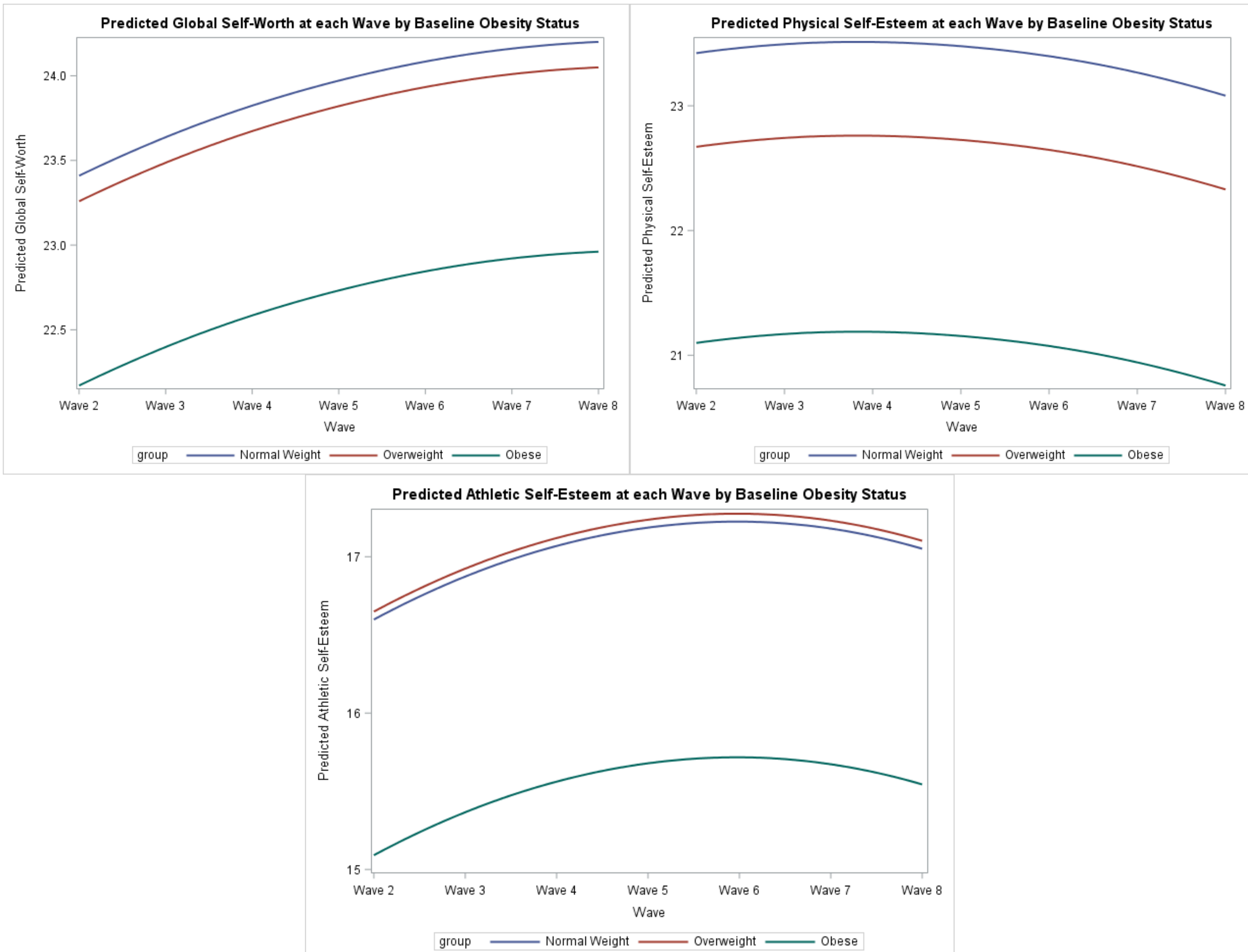
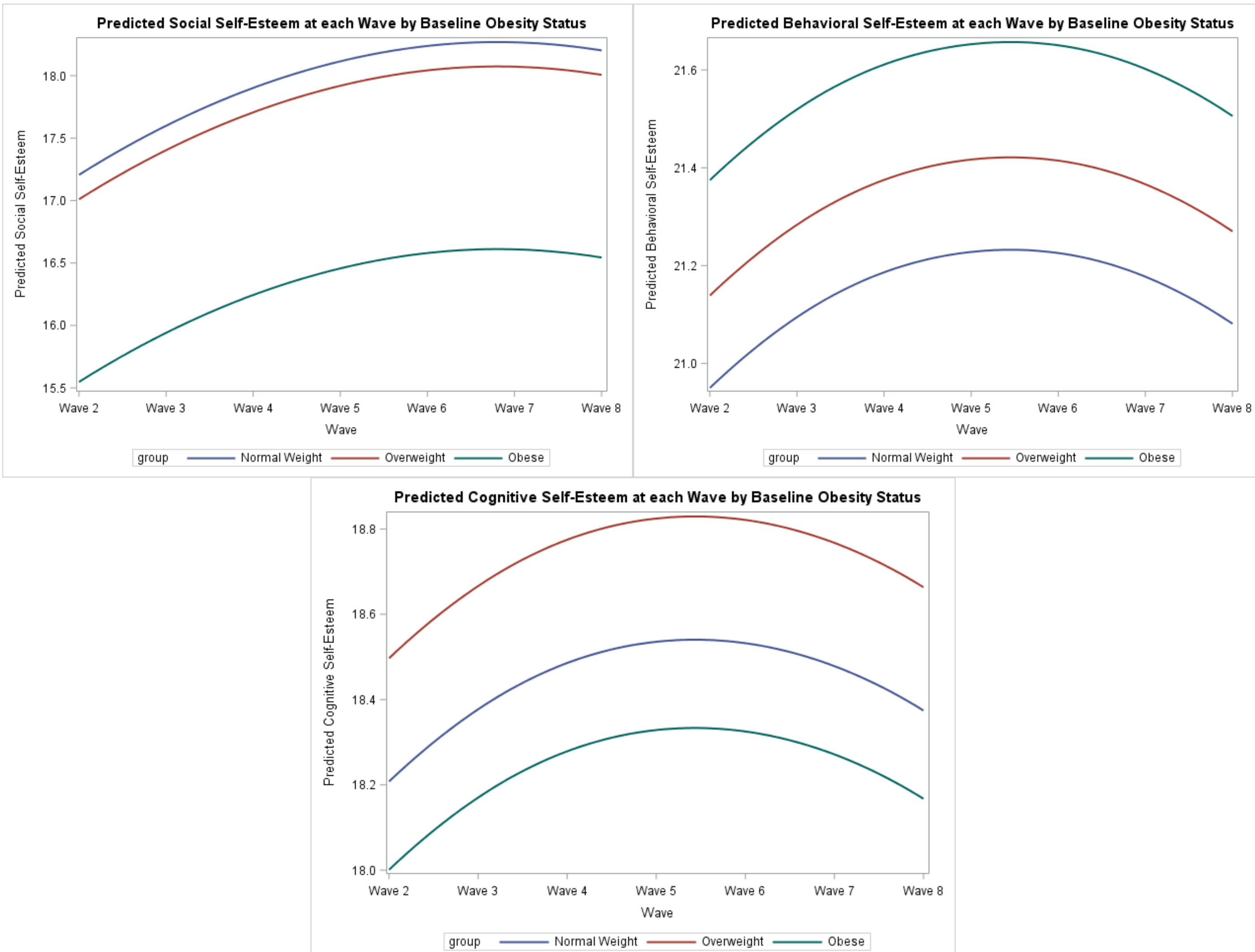


Figure 4.4., continued.



4.3.2 Standardized body mass index as a predictor of self-esteem. To answer the secondary research question of whether having a significantly different body mass (measured in the form of a cohort-constructed z-score) impacts self-esteem, three additional models were created (Table 4.5). These mixed-effects longitudinal models were based off the first set of models above, with the substitution of BMI z-score for crude BMI score. As well, since baseline weight status was categorized using BMI, this variable was removed from these models so that only z-scores were present. No significant interactions existed, so these did not remain in the models. As mentioned, these standardized scores were not created based off international population cut-offs, but from the sample itself based on wave and sex. This will address the same research goal, but anticipates to identify if youth having body mass much different than those around them has a greater impact on self-esteem than raw body mass scores.

The results of the linear mixed-model analyses using BMI z-scores in these three domains were very similar to those found in the original models. The highest effect estimates were among the physical appearance self-esteem domain, as an increase in BMI z-score of one unit predicted a decrease in self-esteem by 1.31 units (95% CI: -1.42, -1.20, $p<0.0001$). In other words, for a subject that has a body mass index one standard deviation greater than the mean of their age and sex in the sample, this estimates a significantly lower physical self-esteem score by more than one unit. Conversely, a subject with a BMI one SD lower would be predicted to have a significantly greater self-esteem by the same margin. The global and athletic domain score changes with BMI z-score were both significant ($p<0.0001$) as well, and predicted self-esteem reductions by 0.53 (95% CI: -0.62, 0.43) and 0.29 (95% CI: -0.38, -0.19) units, respectively. These effect estimates are an average seen throughout the seven study waves, and are not particular to one time interval. Just as in the original model, being male was a significant predictor ($p<0.0001$) of greater physical and athletic self-esteem, and greater physical activity predicted significantly higher ($p<0.0001$) self-esteem in all three of the modified models.

Table 4.5. Estimated change in self-esteem domain scores over follow-up in relation to standardized body mass index z-scores and other predictors using linear mixed-effects regression models

	Model 1 (DV= Global SW)		Model 2 (DV= Physical SE)		Model 3 (DV= Athletic SE)	
Variable	**β (95% CI)**	**Sig.**	**β (95% CI)**	**Sig.**	**β (95% CI)**	**Sig.**
Intercept	21.06 (18.9, 23.2)	***	17.83 (15.4, 20.3)	***	15.46 (13.3, 17.6)	***
Study Wave (ref. Wave 2)						
3	0.33 (0.15, 0.51)	**	0.18 (0.025, 0.38)	NS	0.29 (0.12, 0.46)	**
4	0.28 (0.036, 0.52)	*	-0.24 (-0.51, 0.034)	NS	0.28 (0.035, 0.52)	*
5	0.57 (0.22, 0.92)	**	-0.10 (-0.50, 0.30)	NS	0.63 (0.28, 0.98)	**
6	0.38 (-0.076, 0.84)	NS	-0.61 (-1.12, -0.086)	*	0.44 (-0.025, 0.90)	NS
7	0.66 (0.085, 1.23)	*	-0.47 (-1.12, 0.18)	NS	0.55 (-0.023, 1.13)	NS
8	0.50 (-0.29, 1.28)	NS	-1.12 (-2.01, -0.24)	*	0.24 (-0.56, 1.04)	NS
BMI Z-Score	-0.53 (-0.62, -0.43)	***	-1.31 (-1.42, -1.20)	***	-0.29 (-0.38, -0.19)	***
Sex (male)	-0.020 (-0.23, 0.20)	NS	0.86 (0.61, 1.10)	***	1.31 (1.09, 1.54)	***
Age (per year)	-0.19 (-0.40, 0.028)	NS	-0.053 (-0.24, 0.25)	NS	-0.029 (-0.25, 0.19)	NS
PA Score (per unit)	0.062 (0.053, 0.072)	***	0.059 (0.048, 0.070)	***	0.16 (0.15, 0.17)	***

Note: DV= dependent variable, β= coefficient estimate, Sig= Significance, BMI= body mass index, PA= physical activity, NS= non-significant
*****Indicates significance at p≤0.05, ******Indicates significance at p≤0.01, *******Indicates significance at p≤0.0001

4.3.3 Self-esteem as a predictor of body mass index. Based on the literature and the previous analyses, three linear mixed-effects models were constructed to examine any bi-directional effects in the relationship. In each model, body mass index was the dependent variable, and global self-worth, physical self-esteem, and athletic self-esteem average scores were included as the main independent variables in each model separately. The covariates included in the models were time (study wave 2-8), baseline self-esteem status defined by Harter score cut-offs (normal and low), sex (male versus female), age (years), and physical activity score (total units). Again, geography and household income were omitted from the models. When the interactions of any significant predictors in each model were examined, they were all non-significant and thus excluded as well. The factors listed above were considered fixed effects in the model, and the intercepts were added as random effects. As with the first six models, study wave was specified as a repeated measure, the between-within method was used as the degrees of freedom method, unstructured covariance matrices were created, and the Tukey adjustment method was used to calculate adjusted means.

Global self-worth was included in model 1, physical self-esteem in model 2, and athletic self-esteem was used in model 3 (Table 4.6). All three had intercepts relatively close to each other at 18.48, 18.67, and 18.23 kg/m^2 respectively, all of which were significant at the $p<0.0001$ level. In all three models, BMI changed with study wave in almost the exact same manner, as it increased by almost the same margin at each subsequent wave compared to wave 2. At wave 3, each model predicted an increase of average BMI by 0.35 units ($p<0.0001$), increasing at each wave up until wave 8 which had differences from baseline of 2.68, 2.60, and 2.67 kg/m^2, respectively for the three models. The BMI increases at each wave in each model were significant at $p<0.0001$. With each unit increase in global self-worth score, BMI decreased by 0.024 kg/m^2 (95% CI: -0.032, -0.017, $p<0.0001$) over time, on average. With each unit increase in physical appearance self-esteem score, BMI decreased by 0.044 (95% CI: -0.051, 0.037, $p<0<0.0001$) units on average. And with each unit increase in athletic ability self-esteem score, BMI decreased by 0.017 (95% CI: -0.025, -0.0084, $p<0.0001$) units on average. Compared to those who were considered to have normal self-esteem at baseline, BMI scores increased, on average, by 0.31 kg/m^2 (95% CI: 0.026, 0.60 $p<0.05$) for those who were considered to have low global self-esteem, by 0.39 kg/m^2 (95% CI: 0.12, 0.67, $p<0.01$) for those with low physical self-esteem, and by 0.26 (95% CI: -0.036, 0.56, $p=0.0787$) kg/m^2 for those with low athletic self-esteem at baseline. These predicted changes are the average effects over the five year period. For all three models, sex and age were non-significant predictors of BMI changes although males had slightly lower BMI; and mean BMI scores increased with age. Total physical activity score was a significant covariate in all three models, predicting a lower average body mass index of 0.0074-0.0084 ($p<0.01$), with each unit increase in PA score.

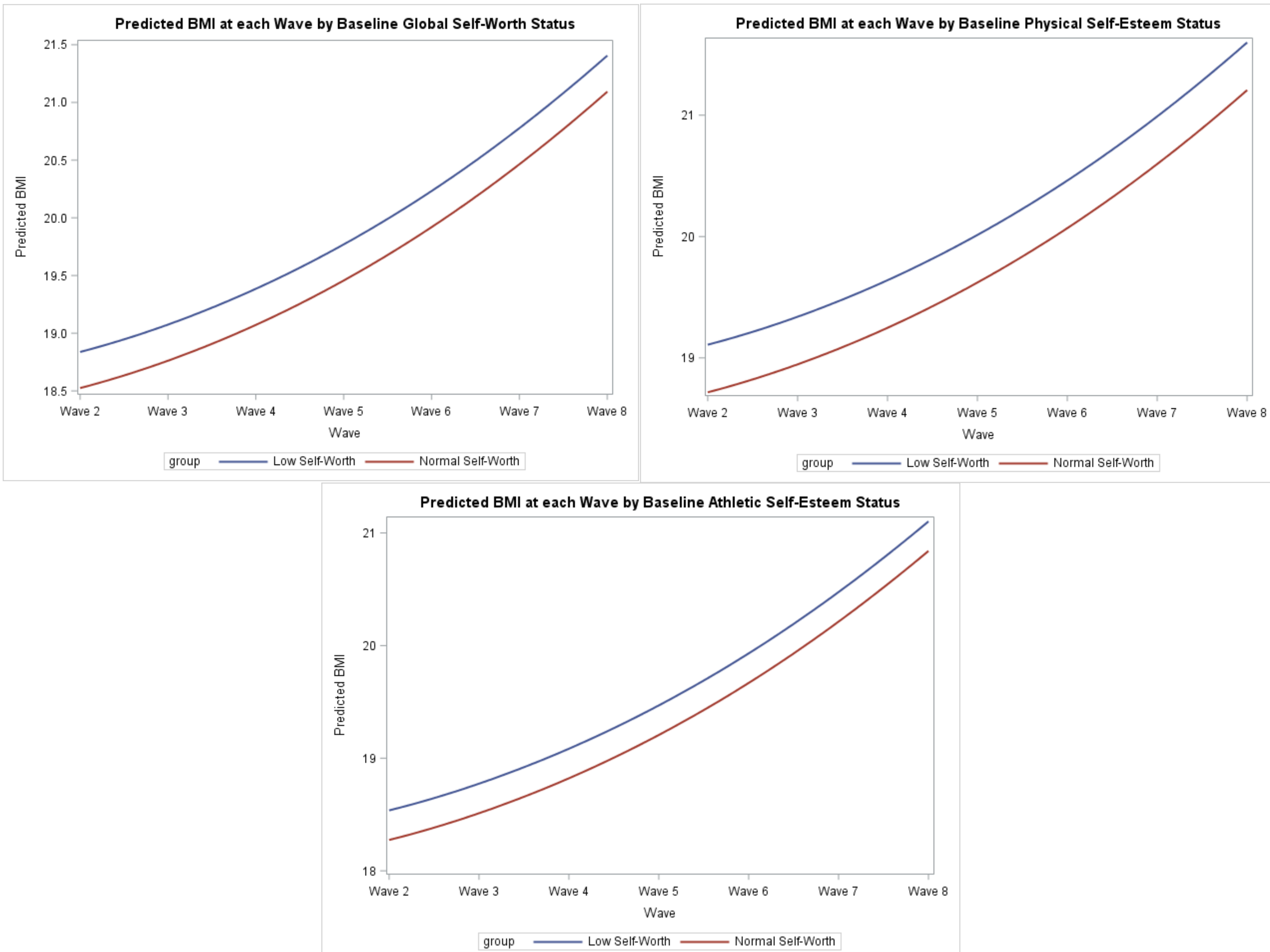
Figure 4.5 displays the predicted mean body mass index according to baseline self-esteem status, for the global, physical, and athletic domains. Although all three graphs reveal the general same pattern of those with low self-esteem having greater BMI, the difference in BMI slope magnitude is the largest for the physical appearance self-esteem groups, whereas the difference is the smallest among the athletic self-esteem groups.

Table 4.6. Estimated change in BMI scores over follow-up in relation to domain-specific self-esteem and other predictors using linear mixed-effects regression models

Variable	Model 1 (IV= Global SW) β (95% CI)	Sig.	Model 2 (IV= Physical SE) β (95% CI)	Sig.	Model 3 (IV= Athletic SE) β (95% CI)	Sig.
Intercept	18.48 (17.3, 19.7)	***	18.67 (17.4, 19.9)	***	18.23 (17.0, 19.4)	***
Study Wave (ref. Wave 2)						
3	0.35 (0.27, 0.44)	***	0.35 (0.27, 0.44)	***	0.35 (0.27, 0.43)	***
4	0.60 (0.48, 0.72)	***	0.58 (0.45, 0.70)	***	0.60 (0.48, 0.72)	***
5	1.02 (0.83, 1.20)	***	0.99 (0.81, 1.18)	***	1.01 (0.83, 1.20)	***
6	1.41 (1.16, 1.66)	***	1.36 (1.11, 1.61)	***	1.41 (1.16, 1.66)	***
7	1.91 (1.59, 2.22)	***	1.85 (1.54, 2.17)	***	1.90 (1.59, 2.21)	***
8	2.68 (2.25, 3.10)	***	2.60 (2.17, 3.02)	***	2.67 (2.25, 3.10)	***
SE Score (per unit)	-0.024 (-0.032, -0.017)	***	-0.044 (-0.051, -0.037)	***	-0.017 (-0.025, -0.0084)	***
Baseline SE~ (low)	0.31 (0.026, 0.60)	*	0.39 (0.12, 0.67)	**	0.26 (-0.036, 0.56)	NS
Sex (male)	-0.13 (-0.41, 0.15)	NS	-0.081 (-0.36, 0.20)	NS	-0.10 (-0.38, 0.18)	NS
Age (per year)	0.071 (-0.048, 0.19)	NS	0.081 (-0.040, 0.20)	NS	0.074 (-0.046, 0.19)	NS
PA Score (per unit)	-0.0084 (-0.013, -0.0034)	**	-0.0074 (-0.012, -0.0025)	**	-0.0076 (-0.013,- 0.0026)	**

Note: IV= independent variable, β= coefficient estimate, SE= self-esteem, Sig= Significance, PA= physical activity, NS= non-significant
*****Indicates significance at p≤0.05, ******Indicates significance at p≤0.01, *******Indicates significance at p≤0.0001
~Low self-esteem status defined as mean domain score <12

Figure 4.5. The predicted slopes of mean BMI scores according to baseline global, physical, and athletic self-esteem status



Chapter 5 Discussion

5.1 Overview

In the descriptive analyses of self-esteem over time, the average trend of most self-esteem domains showed an increase from baseline age, then reductions starting between ages eleven and twelve, with marked decreases after age twelve. Weight-related measures such as weight and body mass index consistently rose throughout childhood and adolescence. When examining mean self-esteem levels according to a participant's baseline weight status, it was consistently found that those who were obese had much lower self-esteem scores throughout the study period. To a lesser extent, those who were overweight at baseline also had lower self-esteem levels than normal weight peers, but not exhaustively. The sub-scales of physical appearance self-esteem, global self-worth, and athletic ability self-esteem most demonstrated this conclusion with the largest mean differences, while maintaining relatively uniform patterns between groups. When examining longitudinal BMI trajectories between normal and low self-esteem participants identified at baseline, BMI was higher for those with low baseline self-esteem at each time-point, in the global, physical, and athletic self-esteem domains. Correlation analyses revealed significant weak to moderate negative linear associations between weight-related measures and physical appearance self-esteem, indicating decreased self-esteem scores with higher body mass throughout the study. This relationship was also weakly observed in global and athletic domains, with very small or no effects among the social, behavioral, and cognitive sub-scales. These correlation coefficient magnitudes were most significant in the body mass index and waist circumference correlations, with somewhat smaller associations among crude weight. The findings were consistent when also examined using both baseline weight status categorizations and BMI z-scores. The primary longitudinal analysis accounting for covariates revealed that increases in BMI predicted significantly lower self-esteem scores over time, and these effects were stable throughout the study period. The largest effects were observed in physical self-esteem then global self-worth, with small yet significant magnitudes in the athletic and behavioral domains. These effects were not found in the social and cognitive (scholastic) areas. Baseline weight status was also a useful predictor of self-esteem scores longitudinally, where being obese significantly predicted lower self-esteem in the physical, global, athletic, and social domains in comparison to normal weight subjects. Among those who were overweight, only significant physical appearance self-esteem reductions were found in comparison to normal weight subjects throughout the study period. Among the physical and athletic realms, being male predicted significantly higher levels of self-esteem, but lower average behavioral self-esteem. In the physical domain specifically, the interaction of obesity status and sex demonstrated that overweight and obese males have lower reductions in their self-esteem than females. For every iteration of the model, it was found that increases in physical activity predicted significantly higher self-esteem, a relationship that was even more augmented among obese subjects through an interaction effect. Similar findings were observed where increases in BMI cohort z-scores predicted lower self-esteem throughout the five-year follow-up, particularly in the physical, global, and athletic realms. These standardized BMI models frame the research question differently, and demonstrate how comparisons made between individuals in the same setting can lead to self-esteem decreases, not just crude BMI score alone. In the temporally-reversed models examining physical, global, and athletic self-esteem as predictors of body mass, it was found that higher self-esteem at baseline and throughout the study period led to significantly lower body mass index levels longitudinally, and lower self-esteem predicted BMI increases. This finding suggests a potential bi-directional pathway between self-esteem and obesity in youth. Once again, physical activity was a significant covariate where increases in total physical activity score predicted significantly lower BMI over time, however sex was not a significant covariate in the reversed models. Overall, all three frameworks in which the research questions were presented provided significant results expanding on previous literature on the topic.

5.2 Key Findings

The aim of this research study was to examine the longitudinal relationship between self-esteem and obesity and examine the potential bi-directionality among Canadian youth. The previous literature with regard to prospective studies in this field summarized that those children or adolescents more obese at baseline had considerably lower global self-worth and physical self-esteem scores at follow-up. This study examined this relationship in more depth and was able to confirm previous findings, as well as address gaps in the literature pointing to new conclusions.

Most of the previous studies examined how body mass index predicts global self-worth, which indicates a person's overall feelings towards themselves. This study included global self-worth, but also examined how each of the other Harter Scale child self-esteem sub-domains are impacted by body mass as a raw score, standardized score, and categorized level. The strongest association found here was between body mass index and physical appearance self-esteem over time, with respect to baseline obesity status (both overweight and obese groups), crude BMI score, and cohort-constructed BMI z-score. O'Dea's (2006) study among 12-13 year old females found that after a three-year follow-up among all domains, the most significantly impacted by obesity group (75^{th} percentile) was the physical appearance score (O'Dea, 2006). This is consistent with our findings in that although their study found a difference between global self-worth of the lowest and highest BMI groups (but did not reach significance at follow-up), physical appearance was most significantly reduced over time.

In our findings, global self-worth had the second highest effect size after physical appearance, and lower GSW throughout time was predicted by BMI (raw and z-score) and baseline obese status, but not overweight. The study by Strauss (2000) only included the global and cognitive domains in a four-year follow-up of children 9-10 years old. They found that by 13-14 years of age, obese (95^{th} percentile) boys and non-Black obese females had significantly lower global self-worth than their non-obese counterparts (Strauss, 2000). Similar results were produced by Sutter et al, indicating that population-based BMI z-scores (CDC) predicted significant decreases in global self-worth over a six-month follow-up for white adolescents (Sutter et al., 2015). In the prospective studies examined, none found a significant longitudinal relationship in any domains besides physical appearance and global self-worth. Our study was able to conclude additional significant findings in the athletic, social, and behavioral domains. BMI was a significant predictor of lower average athletic and to a small extent behavioral self-esteem. Being obese at baseline was also a significant predictor of reductions in both athletic and social self-esteem, however like the global domain the relationship was not found among the overweight groups. Wang's analysis of Canadian 10 and 11 year-old children found similar results in that after four years, only those who were considered obese at baseline (WHO) were significantly more likely than normal weight children to report low general self-esteem (internal scale <15th percentile), but not those considered overweight (Wang et al., 2009). Our study was able to retain a large sample size at each study wave, and suggests that other domains of self-esteem are influenced over time by excess weight measures. Previously, only cross-sectional analyses were able to find significant associations between BMI and other Harter domains such as athletic competency self-esteem (Danielsen et al., 2012; Southall et al., 2004). Congruent with the literature, our models did not find any longitudinal relationship between weight-related factors and cognitive (scholastic) self-esteem and did not associate baseline weight status with behavioral self-esteem. It is important to note that based on the constructed models, the effects of BMI on self-esteem levels and vice versa were stable over time, and presented as average effects throughout the five-year period.

It is evident that excess body mass leads children and adolescents to perceive themselves as having a worse physical appearance and increases unhappiness with the way their body, face, or hair looks. Since Harter has demonstrated that among adolescents physical appearance makes up the largest portion of global self-worth, this could explain why both of these domains were most significantly impaired. Among an age group that primarily relies on peer approval, if children make comparisons to those around them, it makes sense that having a visibly higher body mass in the form of increased central adiposity (indicated by BMI or waist circumference), will lead to a reduced sense of physical attractiveness. Physical appearance self-esteem was the only sub-domain modified by being even overweight (85^{th} percentile) at baseline, suggesting that even relatively small differences in body shape from the norm can result in lower self-esteem.

Athletic and social self-esteem were predicted to be significantly lower among those who were obese at baseline. These two factors may be impaired for a variety of reasons. Athletic self-esteem describes one's self-perceived athletic abilities including doing well at sports and outdoor games. It is possible that once again in comparisons with others, those that have elevated body mass may see themselves as having less athletic prowess. For example, in physical education classes, comparisons may be made with others who may look more physically fit, thus leading to potential feelings of lesser speed, strength, and ability to succeed in competitive activities due to their size or weight. It is also possible that those who are obese may get less physical activity or spend less time in organized sports, thus reducing their actual athletic experience and capabilities. Social competency includes one's perceived ability to succeed in social situations including making friends, and was similarly impaired by baseline obesity but not overweight. Since obesity in children is defined as those in the 95^{th} body mass index percentile for sex and age, these subjects only have the same classification as 5% of the population. Thus, the large majority of the others around them theoretically have a smaller body size, which poses the potential for peer teasing and bullying along with social isolation. Feeling that one is different or stigmatized from the rest of their peers may understandably lead to a perceived reduced ability to be social, fit in, or make friends. The association of BMI and athletic self-esteem has been observed in prior cross-sectional studies (Danielsen et al., 2012; O'Dea, 2006), however not in prospective studies, potentially due to the low number of studies including this factor, or the low sample sizes used in a prospective manner.

The behavioral and cognitive (scholastic) sub-domains of self-esteem had borderline or no associations with body mass or weight status, and are defined by one's perceived ability to behave correctly, and do well in school, respectively. It makes sense that these factors may not have any bearing on one's body weight or obesity status. This could be explained since these particular domains may be appraised on an individual-basis and not based on physical comparisons to others. For example, a child's perceived ability to behave as they are supposed to would potentially depend on rules, expectations, and disciplines enforced by their parents or teachers, and not by how they look in comparison to the peers around them. Similarly, their perceived scholastic aptitudes would also be made by expectations from their parents, teachers, or peers in regard to school work and grades, a factor that may be irrelevant to body shape or size. Strauss' (2000) study which included scholastic self-esteem longitudinally also observed no differences in these scores among any groups over time (Strauss, 2000).

Previous studies indicated that self-esteem is far less impaired for black individuals compared to Caucasians, especially for females. This consistent finding is plausible due to the social norms that are different among certain races or cultural groups, leading to body mass-related comparisons being specific to those they most associate with or hold in high regard. As mentioned, this study was not able to account for race-related differences due to the population-drawn sample from the Niagara Region of Ontario, Canada. However, sex-related differences in self-esteem were able to be included in the analysis and examined.

It has been widely observed that child and adolescent females have lower overall and domain-specific self-esteem, however the effect sizes have been particularly low and usually non-significant in the comparison to males of the same age. This study found that at baseline, some significant differences existed in the self-esteem of males and females, where males had higher physical and athletic self-esteem, but lower behavioral self-esteem. Similarly, in the longitudinal models, being male predicted significantly greater physical and athletic self-esteem, but lower behavioral self-esteem over time. Other domains did not reveal differences in longitudinal self-esteem dependent on sex. These results were consistent with previous literature that reported significantly lower self-esteem among females (Abdollahi et al., 2016; Fedewa et al., 2016; Nowicka et al., 2009; Wang et al., 2009). However, it is now apparent that although this relationship has been generalized in the past, we can conclude that only specific sub-domains of self-esteem are significantly impacted by sex.

The model examining BMI's impact on physical self-esteem also included an interaction term for sex and baseline obesity status. In general, the model shows that physical self-esteem is lower for females, decreases for those who were overweight, and is reduced even further in those who were obese. However, the interaction of sex and obesity status demonstrates that compared to overweight (β=22.61) and obese females (β=21.04), overweight and obese males have higher physical self-esteem of β=23.15 and β=22.20 units, respectively. This represents a 1.16 unit increase in the obese group, a slope much greater than the 0.55 unit average increase for all males in the model. This suggests that the physical appearance self-esteem of females is far more negatively impacted by obesity increases than males.

Throughout every model, it was concluded that age was a non-significant covariate. It has been well established that body mass measures increase and self-esteem measures typically decrease throughout childhood and adolescence. This was demonstrated by the coefficients of the wave variable in the model, in comparison to the baseline wave. Therefore, it is misleading that age did not have an impact on these outcomes as well. The most evident explanation of these findings is that both variables were simultaneously present in each model, and thus the factor of time was over-controlled for by both wave and age due to the multicollinearity of these factors. To understand the effect of time on the relationship between obesity and self-esteem in an unbiased manner, one of these variables should be removed to observe the outcomes. By removing the wave variable which exists categorically in seven intervals, and keeping the age variable which exists as a continuous factor, the effect of time on the relationship can be explored more thoroughly. By subsequently adding an interaction term of age*BMI into the model, this allows BMI's impact on self-esteem to be tested through changes in age (time).

It was already concluded that the effect of BMI on self-esteem is stable over time, as average effect sizes throughout the five year study period were presented. However, by modifying the analyses, it can be explored whether these effects change over time or get stronger or weaker with age. The first six models were altered as explained above, and are presented in Appendix E. Any non-significant interactions were removed from the models, however the age-BMI effects were kept for illustrative purposes. Overall, the main effect of age on self-esteem was that the Global (NS), Physical, and Behavioral domain scores decreased through time, and the Social, Athletic, and Cognitive (NS) domain scores increased through time. The age-BMI interactions were non-significant among five of the six domains, confirming that the effect of BMI on self-esteem does not differ across age, and is stable through time as previously concluded. Only the Athletic self-esteem domain saw a significant negative interaction (β=-0.012, $p<0.05$), indicating that the impact of body mass index on self-esteem is more pronounced with age, as the domain score decreases further with changes in time.

Of the small handful of studies that have examined the obesity/ self-esteem relationship using a BMI z-score, even fewer of these studies have used the multi-dimensional Harter Scale as a measure of self-esteem, nonetheless examined the relationship prospectively (Nowicka et al., 2009; Taylor et al., 2012). The identified study matching this criteria by Sutter et al. (2015) found that with every unit increase in BMI z-score (CDC) over a six-month clinical follow-up in 10-16 year olds, global self-worth decreased by 0.14 units ($p<0.05$) on average (Sutter et al., 2015). Although the regression coefficient in our model was β=-0.42 for global self-worth, key differences exist in the study setting, follow-up time, and creation of the z-score. Our study is the only one to date that creates BMI z-scores based on those in the same cohort utilizing age and sex, rather than using WHO or CDC international population cut-offs. The goal of using BMI z-scores as the independent variable is to isolate how the actual differences among peers in body shape and size can lead to self-esteem changes. Theoretically, the results should be very similar to those using crude BMI scores, but it is plausible that the raw BMI scores just act as a proxy for one's body size in comparison to those around them in terms of self-esteem. Our models were able to conclude that an increase of one standard deviation in BMI above the group's mean predicts lower self-esteem scores in specific domains. The most significantly impacted was physical self-esteem whereby the strongest effect size of β=-1.31 (95% CI: -1.42, -1.20, $p<0.0001$) was observed. Global and athletic self-esteem were also significant at this level, however their effect sizes were much lower at -0.53 (95% CI: -0.62, -0.43), and -0.29 (95% CI: -0.38, -0.19), respectively. These results present similar findings to those of the first models, however it can be concluded that it is not necessary one's BMI that leads to self-esteem changes, but how their BMI varies from those around them. Since self-esteem is defined in-part by social comparisons made with others, it makes sense that relative score differences were able to demonstrate significant findings as well. It is possible that BMI differences contribute more to self-esteem than once thought, and this will come especially relevant when observing this relationship among different settings and cultural groups. Future research will be necessary to compare these two measures to understand whether crude BMI or BMI z-score is a better predictor of self-esteem changes.

This study was one of few that examined the potential bi-directional relationship between self-esteem and obesity in a longitudinal manner. The models indicated that increases in self-esteem scores significantly predicted average reductions in body mass index over time, specifically for global self-worth, physical self-esteem, and athletic self-esteem. Furthermore, having a low baseline global and physical self-esteem predicted significantly higher body mass index at follow-up. French (1996) found similar results in that baseline physical appearance and social acceptance self-esteem were inversely correlated to BMI after a three-year follow-up period, in females only (French et al., 1996). In an early study, O'Brien (1990) observed that high levels of self-esteem at baseline were related to decreased body fatness after 1-3 years in children who were obese at baseline (O'Brien et al., 1990). Wang, however examined this relationship using mixed linear models, and concluded that baseline internally-scaled self-esteem did not predict excess weight after two and four years (Wang et al., 2009). A proposed bi-directional relationship was identified as a gap in the literature, due to the low number of studies examining this and the conflicting results as described above. We can conclude that there are specific domains of self-esteem that can influence one's body mass over time. Although the mechanism of this relationship has not been studied in extent, it is possible that a cyclical effect of these factors exists. If a child with low self-esteem thinks negatively about themselves, this also could lead to social isolation, bullying, and coping mechanisms such as excess eating. In turn, these factors could result in weight gain and obesity over time, which may reinforce their low self-esteem. This complicated pathway should be studied more extensively to understand the relationship between these three factors with taking other related covariate factors into account.

In every iteration of the three distinct models above, physical activity was a significant ($p<0.0001$) independent variable. Measured in total units as an indicator of all self-reported physical activities performed in a set interval of time, it was found that increasing PA scores predicted both higher self-esteem levels and lower body mass index longitudinally. It was the only factor that was significant in every model examined, and even interacted with baseline weight status to show that increased physical activity in those who are obese contributes to a more significantly augmented self-esteem. For example, on average with each unit increase in physical activity score, athletic self-esteem is increased by 0.16. However, among those who are obese, the slope increases to 0.20 ($p<0.01$), meaning physical activity has a greater impact among those who are obese. These results are both logical and agree with literature specific to exercise, BMI, and self-esteem. Wang (2009) found both cross-sectional and temporal relationships between physical activity as a predictor of self-esteem, and observed that children participating in physical activity five to seven times per week were less likely than those participating no more than twice a week to have low self-esteem after four years (Wang et al., 2009). Reddon and colleagues found that in a longitudinal analysis of children also using the PHAST data, increased physical activity was associated with greater global self-worth over four years, with BMI as a mediator (Reddon, Meyre, & Cairney, 2017). Another study utilizing the same data over six years found that physical activity and sport participation were significant yet modestly associated with BMI in both directions as well (J Cairney & Veldhuizen, 2017). It makes sense then that physical activity is a key mediator in the relationship between self-esteem and obesity, however it is important to note that a formal mediation analysis was not conducted. Those who participate in more physical activities may gain the benefits leading to both a lower body mass (increased energy expenditure), and a higher self-esteem (more social and peer interaction, more experience with sports), as well as the effect on self-esteem from a lower body mass itself.

Overall, this study revealed that by examining the longitudinal relationship between youth self-esteem and obesity using three different frameworks, a more comprehensive picture of the relationship could be established.

5.3 Strengths and Limitations

Strengths of this study include the reference study population as well as the analytic methods utilized. The PHAST study recruited a population-based sample of over 2,200 participants at commencement from all schools in the participating regional school board, thus reducing selection bias and oversampling of particular groups. Even though the study featured an open-cohort whereby subjects could enter and exit the study at any time-point, even after this study's selective inclusion/ exclusion criteria, nearly 1,700 were present in the eighth wave. The relatively high retention rate of the original study, along with the addition of subjects throughout led to a powerful sample size for analysis. Additionally, this large sample size allowed the inclusion of separate overweight and obese group classifications which allowed this factor to be examined within the analysis. The study also employed a longitudinal design whereby subject identifiers could be used to track individual-level trajectories for key study variables, and overall patterns could be disseminated. Along with the comprehensive data collection routines employed in the original PHAST study, this analysis accounted for missing data using the Fully Conditional Specification (FCS) multiple imputation regression method. This allowed incomplete cases to remain in the study, thus avoiding the loss of precision and power. The FCS method accounted for different distribution types among the study variables to create its estimates, and was executed with relatively high efficiency thus allowing an increased study validity and the avoidance of information bias. However, one downfall associated with this method was the imputation of a handful of values that stood outside the theoretical limits of specific variables. For example, even with several iterations of the imputation performed, select imputed observations had self-esteem scores greater than the scale's maximum value of 24. The analysis was strong in its primary use of linear mixed-effects modelling, a method that accounts for both fixed and random effects of repeated measurements best suited for the longitudinal data. By utilizing the LMM in the analysis, this allowed for the incorporation of random subject-level effects (e.g. individual intercepts) to account for intra-subject variation. Aside to the robustness of the mixed-modelling, it was important that the study design examined the proposed bi-directional pathway between self-esteem and obesity. By including baseline obesity status into the model, a time-related component was introduced thus allowing temporality to be addressed. The third set of models flips the proposed pathway, and examined the relationship in the opposite manner to observe these potential effects. This brings an important dimension to the research and certainly addresses gaps found in the literature in examining a bi-directional and potentially circular relationship. Also, the use of standardized scores in the second version of the model adds an additional element not previously explored in the literature. By using cohort-based BMI z-scores to predict changes in self-esteem, the research is able to specifically narrow down how body mass changes relative to one's peers as opposed to their crude body weight impacts self-esteem.

A limitation of the study is its inability to address some of the concerns brought about in the literature review. Given that the data was sampled from schools in Niagara, Canada there was a lack of racial diversity and reporting, and thus the study findings can only be inferred to the given population. This was an important factor as previous studies were limited in their inclusion of minorities, and the previously observed effect of race could not be examined here. As well, due to the Harter Scale Self-Perception Profile for Children only being used up until wave 8, an extended follow-up into late adolescence could not be achieved due to a different measurement scale being used beyond this point. Additional study waves may have benefitted the analysis by providing further data points and exploring changes in self-esteem and weight-related measurements after elementary school. Another limitation in the analytical methodology comes from the inclusion of constructed self-esteem and weight status categories at baseline. Self-esteem does not have a recognized clinical threshold, however the study used definitions from Harter to categorize relatively low and normal self-esteem levels in the sample. This limitation may introduce information bias in the form of non-differential misclassification. Conversely, there has been extensive work done to define childhood overweight and obesity for age and sex. However, these cut-offs as defined by the WHO are complex and somewhat difficult to apply to a study sample. Where the precise levels are defined according to the sex of the child and their age in months, this study was only able to utilize whole years alive in its classification methods. Although very small theoretically, this limitation may also introduce a level of misclassification bias into the data. As well, due to not enough subjects being classified as underweight or morbidly obese in the sample, the analysis was not able to include these levels. This limits the strength of fully examining a dose-response relationship between outlying obesity groups and self-esteem changes. In general, there is a limitation of using BMI to assess obesity, especially in youth. As in childhood and adolescence, there are rapid increases in weight and height occurring at different times, this could make BMI an unreliable measure to assess body shape and fatness. However, a part of this problem was addressed by using the WHO cut-offs to define obesity and preliminary analyses revealing that BMI amongst other weight-related measures had the largest correlation with self-esteem scores. Physical activity level was found to be a highly significant covariate of self-esteem changes through time, however it is important to take into account that physical activity was self-reported in the PHAST survey, and thus this could introduce recall bias and impact the associations. Furthermore, the physical activity scale used measures only the frequency of participation in activities, but not the duration or intensity. Another limitation of the study is that although the proposed relationship was examined bi-directionally and significant results were found, the necessary analyses to understand these effects in a comparative manner were not conducted. Additional analyses could be done to construct standardized effect estimates to understand the relative strength of a potential causal relationship in both directions, as well as that of BMI z-score compared to BMI. Also, since the first models predicted changes in self-esteem scores in Harter Scale units, these effect sizes may not be entirely intuitive when presented as opposed to changes in BMI. For example, it was found that with each kg/m^2 increase throughout the study, participants' physical appearance self-esteem score decreased by 0.25 units, on average. Since this is an arbitrary scale, and clinical thresholds do not exist, these effects may be difficult to understand and interpret. On their own without any standardization or real-life applicability (ie. a one-unit change may be considered extremely significant), the exact meanings of these effect sizes may need to be further studied.

5.4 Implications and Future Directions

The results of this study point to the importance of maintaining a healthy body mass in youth, as demonstrated by its negative implications on self-esteem levels. Similarly, it is important for children and adolescents to maintain a normal self-esteem, as this was found to be a protective factor against overweight and obesity. Physical activity levels were found to be a potential key mediator in these relationships, and thus its importance should be stressed to children and adolescents by parents, teachers, and public health officials. Since obesity has come to epidemic proportions in North America, with marked increases among youth, the downstream factors including bullying, stigmatization, and self-esteem issues should be paid attention to more carefully. Increased prevention efforts including education around the effects of overweight and obesity, and the importance of physical activity should be recommended for education curricula at the elementary school level. As well, additional resources will need to be planned for the treatment of these resultant psychosocial issues including self-esteem, anxiety, and depression. Besides using education to target obesity and thus self-esteem, additional focus should go into improving the self-perceptions of youth body-image independently. At the societal level, increased inclusiveness of people with larger body sizes in media and advertising would enable overweight or obese youth to feel more confident about their bodies. Observing more prominence of larger bodied individuals may decrease the self-esteem reductions associated with deviating from the cultural norm, by creating a new cultural norm. Also, instead of solely incentivising greater physical activity and normal body weight, greater attention could be drawn bullying and isolation by incentivising inclusiveness amongst peers and greater participation at the school level. Educators should prioritize reducing bullying and stigmatization in their schools as to mitigate low self-esteem.

Although this research was able to examine the relationship through different lenses and expand the knowledge base around multidimensional self-esteem and obesity in youth, there is additional research needed in this field. Most importantly, now that a bi-directional relationship has been established, additional focus should go into examining the temporality and magnitudes of these associations. Longitudinal studies should be conducted to find out if there is one factor that necessarily precedes the other, and which pathway has a greater effect. This study did not directly assess causality among the relationship, but further research addressing the requirements for causality should be conducted. Also, more in-depth analysis should be provided on the examination of standardized z-scores, and the relative impact of these on self-esteem levels compared to crude scores. Studies should draw more attention to the potential mediating factors in these relationships, namely physical activity and the role it plays in both pathways. As well, the inclusion of race was not able to be examined in this study as contrary to findings in the previous literature, so this impact should be studied more thoroughly in the future using racially diverse samples. Studies with extended follow-up periods should be focused on to examine these effects over a longer period of time, and even test them among different age groups and populations.

Chapter 6 Conclusion

In conclusion, this research revealed that aside to cross-sectional correlations, there is a bi-directional relationship between obesity and self-esteem in Canadian youth. Increased weight-related measures and obesity leads to significantly lower self-esteem over time. As well, increased self-esteem leads to significantly lower body mass index over time. An increased standardized deviation of one's BMI as compared to their cohort also leads to significantly lower self-esteem longitudinally. Particularly significant domains of self-esteem in these pathways are physical appearance, global self-worth, and athletic ability self-esteem. Sex was a significant covariate in many of these relationships, as males and females have specific self-esteem domains demonstrating a significantly greater magnitude. The most prominent covariate was physical activity, as it was significant in both pathways. Increased physical activity level led to a decrease in body mass index and an increase in self-esteem over time, even among those who were obese. The findings of this study demonstrate the complexity of this relationship, and can educate children on the importance of maintaining physical activity levels throughout youth, as well as understand the importance of keeping body mass and self-esteem in a desirable range.

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Appendices

Appendix A

Brock University Research Ethics Board Use of Secondary Data Approval

Bioscience Research Ethics Board

Certificate of Ethics Clearance for Human Participant Research

DATE:	8/14/2018		
PRINCIPAL INVESTIGATOR:	LIU, Jian - Health Sciences		
FILE:	18-025 - LIU		
TYPE:	Masters Thesis/Project	STUDENT: SUPERVISOR:	Harish Aggarwal Jian Liu

TITLE: Self-Esteem and Obesity: A Longitudinal Analysis among Canadian Children and Adolescents in Niagara, Canada

ETHICS CLEARANCE GRANTED

Type of Clearance: NEW Expiry Date: 8/1/2019

The Brock University Bioscience Research Ethics Board has reviewed the above named research proposal and considers the procedures, as described by the applicant, to conform to the University's ethical standards and the Tri-Council Policy Statement. Clearance granted from **8/14/2018** to **8/1/2019**.

Appendix B

The Harter Scale Self-Perception Profiles for Children (Susan Harter, 2012a) used in PHAST

What I Am Like

Name______________________ Age____ Birthday _______________ ☐ Boy ☐ Girl

Month Day (check one)

	Really True for me	Sort of True for me				Sort of True for me	Really True for me
			Sample Sentence				
a.	☐	☐	Some kids would rather play outdoors in their spare time	BUT	Other kids would rather watch T.V.	☐	☐
1.	☐	☐	Some kids feel that they are very good at their school work	BUT	Other kids worry about whether they can do the school work assigned to them	☐	☐
2.	☐	☐	Some kids find it hard to make friends	BUT	Other kids find it pretty easy to make friends	☐	☐
3.	☐	☐	Some kids do very well at all kinds of sports	BUT	Other kids don't feel that they are very good when it comes to sports	☐	☐
4.	☐	☐	Some kids are happy with the way they look	BUT	Other kids are *not* happy with the way they look	☐	☐
5.	☐	☐	Some kids often do not like the way they behave	BUT	Other kids usually like the way they behave	☐	☐
6.	☐	☐	Some kids are often unhappy with themselves	BUT	Other kids are pretty pleased with themselves	☐	☐
7.	☐	☐	Some kids feel like they are just as smart as other kids their age	BUT	Other kids aren't so sure and wonder if they are as smart	☐	☐
8.	☐	☐	Some kids know how to make classmates like them	BUT	Other kids don't know how to make classmates like them	☐	☐
9.	☐	☐	Some kids wish they could be a lot better at sports	BUT	Other kids feel they are good enough at sports	☐	☐
10.	☐	☐	Some kids are happy with their height and weight	BUT	Other kids wish their height or weight were different	☐	☐
11.	☐	☐	Some kids usually do the right thing	BUT	Other kids often don't do the right thing	☐	☐

	Really True for me	Sort of True for me				Sort of True for me	Really True for me
12.	☐	☐	Some kids don't like the way they are leading their life	BUT	Other kids *do* like the way they are leading their life	☐	☐
13.	☐	☐	Some kids are pretty slow in finishing their school work	BUT	Other kids can do their school work quickly	☐	☐
14.	☐	☐	Some kids don't have the social skills to make friends	BUT	Other kids do have the social skills to make friends	☐	☐
15.	☐	☐	Some kids think they could do well at just about any new sports activity they haven't tried before	BUT	Other kids are afraid they might not do well at sports they haven't ever tried	☐	☐
16.	☐	☐	Some kids wish their body was different	BUT	Other kids like their body the way it is	☐	☐
17.	☐	☐	Some kids usually act the way they know they are supposed to	BUT	Other kids often don't act the way they are supposed to	☐	☐
18.	☐	☐	Some kids are happy with themselves as a person	BUT	Other kids are often not happy with themselves	☐	☐
19.	☐	☐	Some kids often forget what they learn	BUT	Other kids can remember things easily	☐	☐
20.	☐	☐	Some kids understand how to get peers to accept them	BUT	Other kids don't understand how to get peers to accept them	☐	☐
21.	☐	☐	Some kids feel that they are better than others their age at sports	BUT	Other kids don't feel they can play as well	☐	☐
22.	☐	☐	Some kids wish their physical appearance (how they look) was different	BUT	Other kids like their physical appearance the way it is	☐	☐
23.	☐	☐	Some kids usually get in trouble because of things they do	BUT	Other kids usually don't do things that get them in trouble	☐	☐
24.	☐	☐	Some kids like the kind of person they are	BUT	Other kids often wish they were someone else	☐	☐

	Really True for me	Sort of True for me				Sort of True for me	Really True for me
25.	☐	☐	Some kids do very well at their classwork	BUT	Other kids don't do very well at their classwork	☐	☐
26.	☐	☐	Some kids wish they knew how to make more friends	BUT	Other kids know how to make as many friends as they want	☐	☐
27.	☐	☐	In games and sports some kids usually watch instead of play	BUT	Other kids usually play rather than just watch	☐	☐
28.	☐	☐	Some kids wish something about their face or hair looked different	BUT	Other kids like their face and hair the way they are	☐	☐
29.	☐	☐	Some kids do things they know they shouldn't do	BUT	Other kids hardly ever do things they know they shouldn't do	☐	☐
30.	☐	☐	Some kids are very happy being the way they are	BUT	Other kids wish they were different	☐	☐
31.	☐	☐	Some kids have trouble figuring out the answers in school	BUT	Other kids almost always can figure out the answers	☐	☐
32.	☐	☐	Some kids know how to become popular	BUT	Other kids do not know how to become popular	☐	☐
33.	☐	☐	Some kids don't do well at new outdoor games	BUT	Other kids are good at new games right away	☐	☐
34.	☐	☐	Some kids think that they are good looking	BUT	Other kids think that they are not very good looking	☐	☐
35.	☐	☐	Some kids behave themselves very well	BUT	Other kids often find it hard to behave themselves	☐	☐
36.	☐	☐	Some kids are not very happy with the way they do a lot of things	BUT	Other kids think the way they do things is fine	☐	☐

Appendix C

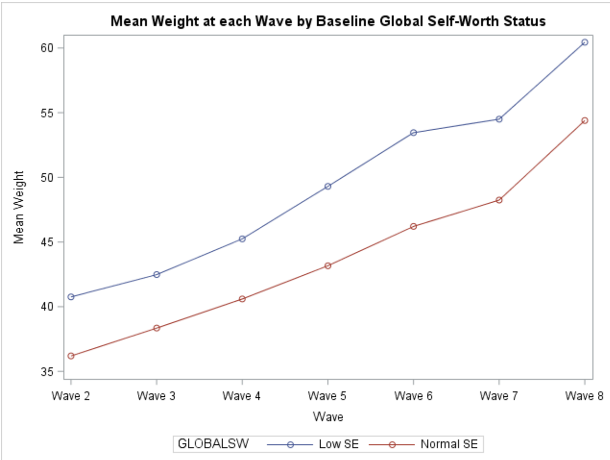
The Mean and SD for Body Mass Index (kg/m^2) by Wave and Sex

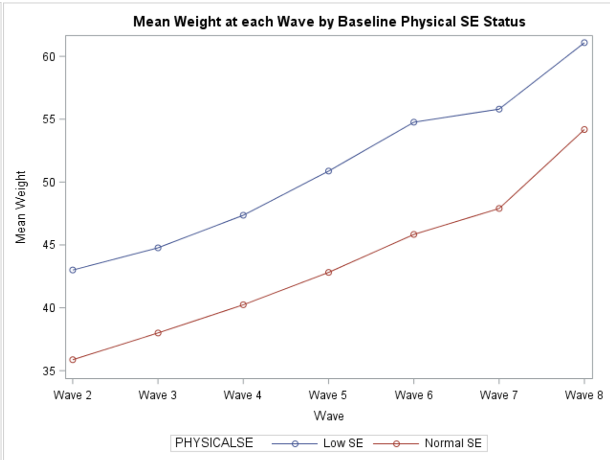
	Males		Females	
	Mean	**SD**	**Mean**	**SD**
Wave 2	18.52	3.47	18.61	3.58
Wave 3	18.93	3.66	18.99	3.74
Wave 4	19.19	3.70	19.24	3.82
Wave 5	19.60	3.92	19.77	4.08
Wave 6	20.00	3.96	20.19	4.13
Wave 7	20.35	4.08	20.32	4.04
Wave 8	21.00	4.15	21.32	4.25

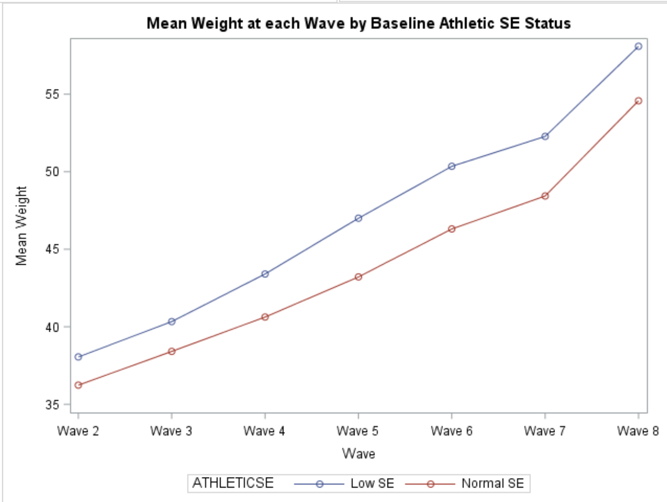
SD= Standard Deviation

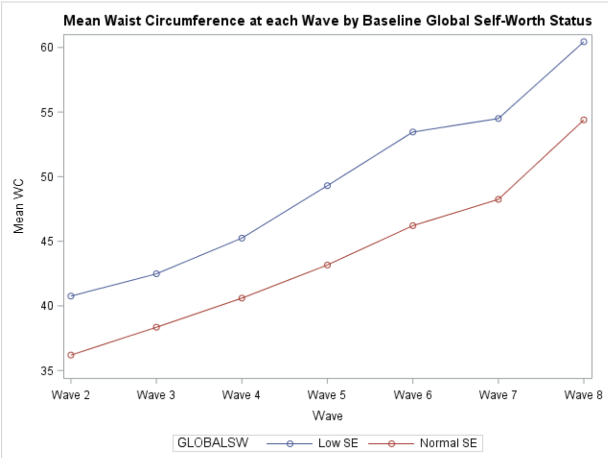
Appendix D

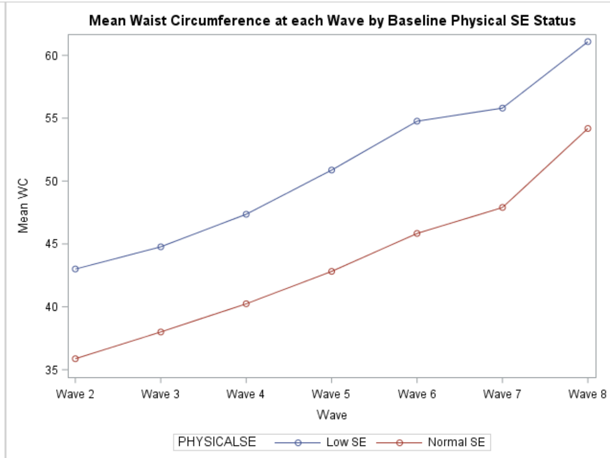
Mean Weight and Waist Circumference at each Study Wave According to Baseline Global, Physical, and Athletic Self-Esteem Status

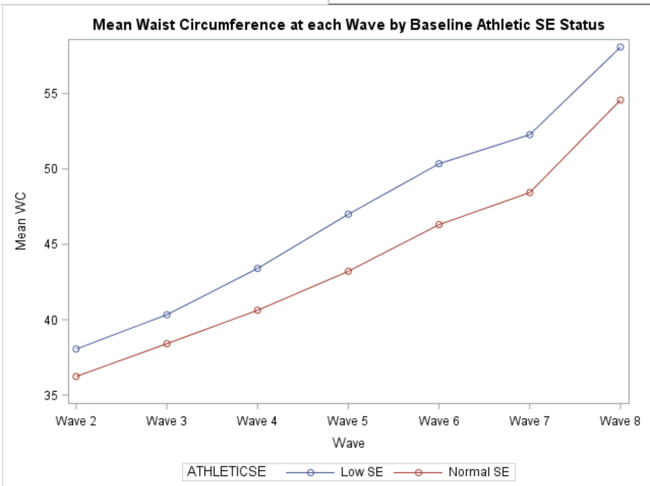







Mean Waist Circumference at each Wave by Baseline Global Self-Worth Status
Mean WC
35
40
45
50
55
60
Wave 2
Wave 3
Wave 4
Wave 5
Wave 6
Wave 7
Wave 8
Wave
GLOBALSW
Low SE
Normal SE


Mean Waist Circumference at each Wave by Baseline Physical SE Status
Mean WC
35
40
45
50
55
60
Wave 2
Wave 3
Wave 4
Wave 5
Wave 6
Wave 7
Wave 8
Wave
PHYSICALSE
Low SE
Normal SE


Mean Waist Circumference at each Wave by Baseline Athletic SE Status
Mean WC
35
40
45
50
55
Wave 2
Wave 3
Wave 4
Wave 5
Wave 6
Wave 7
Wave 8
Wave
ATHLETICSE
Low SE
Normal SE

Appendix E

The Primary Models Adjusted for Age-BMI Interaction

	Model 1 (DV= Global SW)		Model 2 (DV= Physical SE)		Model 3 (DV= Athletic SE)	
	β (95% CI)	Sig.	β (95% CI)	Sig.	β (95% CI)	Sig.
Variable						
Intercept	22.86 (20.33, 25.40)	***	25.65 (22.88, 28.41)	***	12.70 (10.39, 15.0)	***
BMI (per kg/m^2)	-0.18 (-0.32, -0.042)	*	-0.30 (-0.45, -0.16)	***	0.10 (-0.018, 0.23)	NS
Baseline Weight¶ (ref. Normal WT)						
Overweight	-0.11 (-0.60, 0.38)	NS	-0.72 (-1.15, -0.30)	**	0.058 (-0.44, 0.55)	NS
Obese	-1.17 (-2.03, -0.30)	**	-2.28 (-2.95, -1.60)	***	-1.54 (-2.18, -0.89)	***
Sex (male)	-0.050 (-0.27, 0.16)	NS	0.55 (0.25, 0.86)	**	1.29 (1.07, 1.51)	***
Age (per year)	-0.11 (-0.32, 0.093)	NS	-0.23 (-0.46, -0.0026)	*	0.32 (0.13, 0.51)	**
PA Score (per unit)	0.055 (0.043, 0.067)	***	0.055 (0.044, 0.066)	***	0.16 (0.15, 0.17)	***
PA x Overweight	0.0095 (-0.013, 0.032)	NS	--	--	-0.0022 (-0.023, 0.020)	NS
PA x Obese	0.036 (0.0031, 0.070)	*	--	--	0.044 (0.014, 0.074)	**
Male x Overweight	--	--	0.54 (-0.093, 1.17)	NS	--	--
Male x Obese	--	--	1.17 (0.36, 1.98)	**	--	--
Age x BMI	0.0063 (-0.0041, 0.017)	NS	0.0044 (-0.007, 0.016)	NS	-0.012 (-0.02, -0.0026)	*

Note: DV= dependent variable, β= coefficient estimate, Sig= Significance, BMI= body mass index, WT= weight, PA= physical activity, NS= non-significant
*****Indicates significance at p≤0.05, ******Indicates significance at p≤0.01, *******Indicates significance at p≤0.0001
¶Overweight status defined in the top 85-95% BMI WHO cut-offs, Obese status defined in top 5% BMI WHO cut-offs

The Primary Models Adjusted for Age-BMI Interaction, continued

Variable	Model 4 (DV= Social SE) β (95% CI)	Sig.	Model 5 (DV= Behavioral SE) β (95% CI)	Sig.	Model 6 (DV= Cognitive SE) β (95% CI)	Sig.
Intercept	14.06 (11.49, 16.64)	***	20.37 (17.65, 23.10)	***	15.99 (13.38, 18.60)	***
BMI (per kg/m^2)	0.031 (-0.11, 0.17)	NS	-0.023 (-0.17, 0.13)	NS	0.077 (-0.064, 0.22)	NS
Baseline Weight[¶] (ref. Normal WT)						
Overweight	-0.16 (-0.75, 0.44)	NS	0.19 (-0.23, 0.60)	NS	0.26 (-0.12, 0.65)	NS
Obese	-1.61 (-2.36, -0.86)	***	0.41 (-0.34, 1.16)	NS	-0.27 (-0.90, 0.36)	NS
Sex (male)	-0.091 (-0.33, 0.15)	NS	-1.65 (-1.89, -1.40)	***	0.0061 (-0.24, 0.26)	NS
Age (per year)	0.33 (0.12, 0.54)	**	-0.032 (-0.25, 0.18)	NS	0.13 (-0.079, 0.34)	NS
PA Score (per unit)	0.094 (0.082, 0.11)	***	0.049 (0.039, 0.059)	***	0.077 (0.067, 0.087)	***
PA x Overweight	0.0060 (-0.019, 0.031)	NS	--	--	--	--
PA x Obese	0.046 (0.012, 0.079)	**	--	--	--	--
Male x Overweight	--	--	--	--	--	--
Male x Obese	--	--	--	--	--	--
Age x BMI	-0.0026 (-0.13, 0.0081)	NS	-0.002 (-0.013, 0.0091)	NS	-0.0085 (-0.019, 0.0023)	NS

Note: DV= dependent variable, β= coefficient estimate, Sig= Significance, BMI= body mass index, WT= weight, PA= physical activity, NS= non-significant
*Indicates significance at p≤0.05, **Indicates significance at p≤0.01, ***Indicates significance at p≤0.0001
¶Overweight status defined in the top 85-95% BMI WHO cut-offs, Obese status defined in top 5% BMI WHO cut-offs